Illuminating Engineer

XXVII. May, 1934 Price 9

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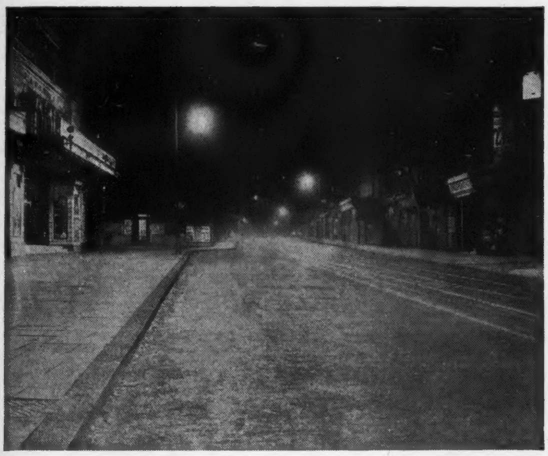

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The
ILLUMINATING ENGINEER
THE JOURNAL OF GOOD LIGHTING

Edited by

J. STEWART DOW

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Principal Contents:

Light and Safety on the Roads.

THERE is every cause for grave concern at the ever-mounting list of accidents on the roads. Every year nearly a quarter of a million people are killed or injured.

How far can good public lighting help to reduce these appalling figures? That it *can* do so we all confidently believe, but it is less easy to prove this by actual facts and figures.

It has, however, been shown (see ILLUMINATING ENGINEER, July, 1933, pp. 174—176) that the number of accidents occurring in darkness is to-day actually *half* the number occurring during daylight—surely a very striking ratio, and one that has been steadily increasing year by year.

It has also been shown beyond question that security on the roads is much less by night than by day—a disparity that only better artificial lighting can remedy.

The Road Traffic Act now before Parliament proposes a speed limit of 30 miles per hour in "built-up areas"—which are defined as areas where a system of lighting is maintained out of the rates.

Now the exact description of "built-up areas" is admittedly a difficult problem. But it is surely unfortunate, psychologically, to adopt a method that might be interpreted as meaning that a speed limit is needed on a lighted road, but not on one in complete darkness! Moreover, street lamps are not always evident in daylight; nor, when installed, are they always switched on throughout the entire night.

Therefore it would be wise in all doubtful cases to adopt *direct* auxiliary methods, such as the display of a distinctive warning sign.

Street Lighting and Speed Limits

A curious point arises in connection with the recently introduced Road Traffic Bill, imposing a speed limit of thirty miles per hour in built up areas. The definition of exactly what constitutes a "built up area" is obviously a matter of some difficulty, and is met by the ingenious expedient of assuming such an area to exist wherever there is a system of public lighting, maintained at the expense of the rates (unless a length of road is exempted by special order). This association of ideas does not seem quite a happy one. There is some danger that road lighting may be regarded as synonymous with speed limits. This may complicate discussions on improvements in public lighting, though it seems unlikely that its effect will be to deter authorities from taking measures to extend existing lighting installations. The method may also involve certain difficulties in practice. I understand that the Ministry of Transport recently received a deputation consisting of leading members of the Council of the Illuminating Engineering Society supported by representatives of the Association of Public Lighting Engineers and other interested bodies. Their views will doubtless receive sympathetic consideration by the authorities, in their effort to deal with a somewhat difficult and complicated problem.

Public Lighting in Leicester

Leicester this year has received *two* reports on public lighting, one of the usual annual statistical survey, the other marking the tenth anniversary of the Lighting Department. The former again records steady progress, especially in electric lighting. During the period 1930-1933 the rated candle-power output of street lighting plant has increased by about 20 per cent. But the cost of public lighting has actually decreased progressively from 5.51 to 4.75 pence per £. The anniversary report contains an interesting survey of the work of the department which has developed considerably since 1933. Mr. Wilkie, in 1923, found on arrival "neither furniture nor records." The new headquarters were officially opened in 1927. I have no doubt that the City Council is fully satisfied that the effort was well worth while. Mr. Wilkie illustrates the activities of his department by remarking that last year the area of glassware cleaned amounted to 262 acres and the number of miles walked by employees to 135,000 miles—equivalent to five and a half times round the world! There is an account of work carried out in the Test Laboratory which should be of service in illustrating how directly "value for money" expended on street lighting depends upon efficient maintenance and periodical tests.

The Dark Case of Orford

As a contrast and a curiosity let us consider the "dark case of Orford," in Suffolk, to which attention was recently drawn in the daily Press. Orford has now no public lighting, apparently because the lighting committee could not meet last year's bill and has been unable to raise funds—even by the aid of whist drives and jumble sales! Strange to say Orford, once a large port with mayor and corporation but to-day only a village, was originally the pioneer of electric lighting in East Suffolk. Its fate illustrates the variety of problems to be faced by those who would have all sections of "the King's Highway" adequately and evenly lighted.

An Age of Tubular Lighting

The increasing part played by the tube in modern lighting is evident. Neon signs are everywhere and the possibilities of colour-lighting have been greatly enhanced by the arrival of electric discharge lamps. I notice that Mr. H. Chevalier, in a contribution to "The Ideal Kinema and Studio" quotes, as an example of this tendency, the impressive colour-lighting of certain buildings at the Chicago World's Fair. I have always been impressed by the possibilities of combinations of gaseous and filament lamps in designs. I suspect, however, that in both cases the most artistic results are possible when the source is concealed from view. Facility in shaping tubular designs should not blind us to the fact that in decorative lighting it is rarely the tube, any more than the filament, that we really desire to see; it would frequently be more effective to use their light in illuminating other objects.

Good Industrial Lighting No. 3

Courtesy Holophane Ltd.
An example of high intensity lighting from local 60-75 watt lamps, spaced 3 ft. 6 in. apart; height 18 in. on side benches, 3 ft. on centre benches.

When Local Lighting Should Be Used

IN the article on "How to Secure Sufficient Illumination," which appeared in our last issue (ILLUMINATING ENGINEER, April, 1934, pp. 113-114), it was remarked that good general overhead lighting answers the requirements of most modern offices and factories. The advantages of the method are evident. It enables a clear view of the whole room to be obtained. The height of the lighting units, out of the direct range of vision, gives comparative freedom from glare. Large lighting units are usually more efficient than small ones. The maintenance of a few large units presents less difficulty than the upkeep of a multitude of small units. When well-diffused general lighting is adopted it is usually possible to alter the positions of tables or machines without its being necessary to interfere with the lighting above.

These are substantial advantages, and go far to explain the wide use of overhead general lighting. In some cases—in banks, for instance—where local lighting was at one time invariable, it is now quite usual to find general lighting adopted. The preference for local lighting probably arose from the fact that with the low relatively inefficient power lighting units formerly available, mounted at the customary height, one could not readily obtain a sufficiently high illumination for somewhat exacting tasks. The same circumstance explains the practice of lighting even large rooms by means of a forest of pendant units, usually imperfectly shaded and mounted slightly above eye-level—an unsightly method now happily becoming obsolete.

Where Local Lighting Helps.

There are, however, conditions that do favour the use of special local lighting, though usually as a supplement to general lighting rather than as a substitute for it.

One might sum up these conditions as follows. Local lighting is frequently helpful:—

(1) **When a large room** is occupied (sometimes temporarily) only by **a few scattered workers,** so that it is uneconomical to flood the entire room with **bright light.**

(2) When **exceptionally intricate work with minute objects** demands an unusually high illumination (25-50 foot-candles or more), which it is uneconomical to maintain by means of general lighting.

(3) In the case of certain processes where the appearance of an object, or of **small projections on its surface,** is much affected by the degree of diffusion of the light, and where **inspection may be facilitated by ability to alter the inclination at which rays of light are received.**

(4) In the case of **objects having recesses or apertures** which can only be properly explored by the aid of a local light.

(5) In **rooms occupied by bulky and intricate machinery,** which, to a great extent, blocks light coming from above.

(6) In the case of **work on exceptionally dark materials,** reflecting only a small percentage of the light striking them.

(7) When **light of an unusual special colour,** such as "artificial daylight" is desired.

(8) In the case of work imposing an exceptional strain on the worker's attention, and where local lighting helps to **concentrate mental effort.**

Let us then consider some of these cases in greater detail.

The condition involved in (1) may sometimes be met by merely subdividing the switching of lights in a large room, so that only certain sections are operated. This, however, is apt to upset the "balance" of the lighting. If the conditions are of long duration it will usually be found expedient to furnish local lights for these isolated workers. Indeed, in a workshop devoted to varied tasks (as compared with a room occupied by a number of workers all engaged on identical operations) it is almost always expedient to provide outlets so that local lights can be used if needed.

Why Some Workers Like Adjustable Units.

Under the heading (2) one would certainly include all varieties of work in which the use of magnifying lenses or spectacles is customary. Thus a microscope field invariably needs exceptionally high illumination, and local lights would doubtless be used for such processes as hosiery linking mentioned above. Watchmakers and engravers are amongst those who habitually use local lighting, though in this case the reason may be found partly in the conditions indicated in (3). In such cases the choice of an adjustable local light is not determined *only* by the fact that the parts or objects examined are small. Judgment of the worker is guided to a great extent by the appearance of small projections or depressions in the material, which he can best study by adjusting the tilt of the lamp, thus altering the angle at which light is received. Comparative effects of polish of different parts of the same surface may also be of moment. For this reason—although the writer holds that most forms of clerical work can be done quite readily by general lighting—he is inclined to except the case of the cashier or inspecting clerk, who is constantly examining statements copied on flimsy paper with copying-ink pencil. The shiny surface of such handwriting often makes it difficult to decipher, hence there seems some justification for the whims of clerks engaged on this kind of task, who so often beg for an adjustable local lamp which they can manipulate to suit their needs. For such operations as sewing and textile work local lights are also in demand; partly because of the fineness of the work, which deserves a high illumination, and also because here again observation depends on the detection of small shadows cast by the surface of the cloth, such as are apt to be smoothed out by fully diffused general lighting.

The good diffusion characteristic of good modern general lighting enables the light to "see round corners" to a remarkable extent, e.g., sufficiently to enable one to see the contents of pigeon holes or drawers in an office. But cases *do* occur when apertures or recesses are too deep to be reached effectively by general lighting. A typical case was afforded by the examination of the interiors of shell cases during the war, for which special local lamps had to be designed.

The Lighting of Complex Machinery.

It is also a good plan to provide facilities for special local inspection lamps whenever bulky and intricate machinery is to be examined. Printing machinery and textile looms, for example, inevitably obstruct much of the light obtained from overhead lamps, however carefully they are placed. It has, indeed, been suggested that the right course in such cases would be to design the machinery with special mounting places for shaded local lights furnishing illumination at the critical places where one specially needs to see. Effects of vibration would no doubt be a difficulty, but the idea seems by no means impracticable.

Dark Materials Need Extra Light.

Perhaps the most established case for local lighting is to be found in those trades in which very dark material has to be handled, such as garment-making and boot-making. It is easy to understand that sewing dark cloth with black cotton must demand a high illumination—so much greater than that ordinarily furnished as to make local lighting almost essential. If black serge reflects, say, only 5 per cent. of the light reflected by white linen, is it unreasonable to suggest that the former requires twenty times as much light as the latter?

But the problem goes deeper than this. Even supposing that we increase the general lighting twenty times, we still do not meet the case. For the light-coloured walls and ceiling will still appear brighter than the dark working material, so that the latter still appears, by contrast, under-lighted. The correct course, therefore, is to ensure that the illuminated dark material is *the brightest thing within the range of vision*—and this can only be done by using local lighting and allowing the surroundings to be of subdued brightness only.

Artificial Daylight Units.

Local lighting is frequently adopted when light of a special colour is required. At present the chief instance is afforded by "artificial daylight," such as is needed for colour-matching processes. Where only a very approximate resemblance to daylight is needed (and where the absorption of light is therefore not very great), general lighting with units of this type may be adopted. The high degree of accuracy required in many processes in the dyeing industry can only be attained at present by a great sacrifice of light—the absorption being sometimes as much as 80 per cent. The provision of a sufficiently high general illumination (and for such work a relatively high illumination, 20 foot-candles or more, is often desirable) by such methods would naturally be costly. It is therefore natural to attempt only the illumination of the actual area where tests are made, and to use local lights within a booth or cabinet from which uncorrected light is excluded.

Local Lights Aid Concentration.

There remains the general consideration that local lighting is in some degree favourable to mental concentration. One finds that this is instinctively recognised by students and by those practising delicate and skilful arts on which attention must be very closely concentrated. This type of work is essentially individual. On the other hand, in the case of "team work," and where a certain stimulus from brightly lighted surroundings is helpful, alertness and speed rather than sustained mental effort being demanded, general lighting seems to be the right thing.

The Design of Local Lights.

In conclusion, a few words may be said in regard to the nature of local lights. In most cases local lighting is derived from standard forms of lamps mounted about 18 inches from the work, usually in an adjustable form of fitting, so that the lamp can be brought nearer or withdrawn from the work as desired. There are two main points in the design of such apparatus that should be emphasised:

(1) the source of light (filament or mantle) should be *completely screened* from the eyes of the workers;

(2) efforts should be made to reduce to a minimum uneven illumination on the working area.

The fulfilment of this second condition implies absence of "spottiness" or streaks of light. When electric lighting is adopted internally frosted bulbs are preferable to those of clear glass, as the frosting is of material help in eliminating streakiness.

Some General Lighting Always Needed.

One word more. It must always be remembered that local lighting, however excellent, can only achieve its full purpose if moderate general illumination over non-working areas of, say, not less than 1 foot-candle is also provided. This supplementary general illumination is necessary in order that people may find their way about in comfort; and also in order to avoid the strain that is apt to be thrown on the eyes when the gaze is transferred from the brightly-lit working material to complete darkness around. In other words, a moderate contrast in brightness aids concentration and helps vision, but excessive contrast (a form of glare) causes fatigue and should be avoided.

The Lighting of Unilever House

New Bridge Street, London, E.C.

By the courtesy of Messrs. Lever Brothers, Ltd., members of the Illuminating Engineering Society paid a visit to Unilever House, for the purpose of examining the novel lighting arrangements on March 15th.

The thanks of the Society are due to the Electrical Engineer, Mr. W. A. Humphreys, who kindly conducted the party over the building.

[Courtesy The General Electric Co., Ltd.

Figure 1. Unilever House floodlighted by night.

UNILEVER HOUSE occupies a commanding position at the corner of New Bridge Street, adjacent to Blackfriars Bridge, London. The massive architectural features of the building render it an impressive sight when viewed from the other side of the river. The frontage lends itself well to floodlighting by night. (See Fig. 1.)

The main features of the interior lighting are firstly the specially designed and highly modern boxed-in fittings used in the main hall, on the stairs, and elsewhere; and, secondly, the general use of overhead lighting, by means of 200-watt lamps in 14-in. three-ply flashed open glass spheres, for offices. Extensive use is made of luminous surfaces of low brilliancy. There are no exposed lights, and the general effect is restful and restrained.

East Entrance.

At the east entrance there is a flush panel light utilising seventeen 25-watt lamps, and in the vestibule two floodlights, each housing a 300-watt lamp. The main ceiling box-fitting is intentionally brought down 6 in. below the ceiling level in order to give the ceiling some illumination and prevent a general dark effect (which is inevitable when units mounted flush with the surface are used). This idea is followed out with other similar units throughout the building.

This method of lighting is used in offices throughout the building. In the Treasury Department (ground floor) the lamps are spaced on 14-ft. centres. The height of the ceiling is 15½ ft., and the distance from ceiling to centres of light-sources 5½ ft. An illumination of 5-7 foot-candles is furnished on desk tops. In the Mechanised Section (where fine work is done), the same system of overhead lighting is adopted. It is found to answer requirements quite well, and is preferred to local lighting on the ground of easier maintenance. In the General Offices a modification is made in the region of the room where the glass of overhead skylights diminishes reflection of light downwards, clusters of four globes being here substituted.

On the first floor landing lighting units incorporated in the semi-barrel ceiling have a decorative effect. Each unit includes twelve 15-watt lamps. There is a striking view of the lighting at this point from outside the building, through the main entrance fanlight.

Figure 2. A view of the staircase showing the original and effective box fittings.

Figure 3. A typical view of one of the large offices on the first floor, showing general lighting by lamps in diffusing spheres.

Figure 4. The Board Room (fourth floor), equipped with cornice lighting.

Board Room and Special Committee Room.

Features of interest on the fourth floor are the imposing Board Room (Fig. 4) and the Special Committee Room (Fig. 5). In the Board Room the ceiling, 25 feet high, is encircled by cornice lighting, which provides 6 foot-candles on the table. The cornice lighting is effected by 184 internally frosted 60-watt lamps.

Main Hall.

In the Main Hall a feature is the large central spherical fitting for which eight internally frosted lamps are used. The special lighting of the lift deserves special mention. In the panel lights over the lift are seven 25-watt lamps, and for the indirect lighting inside the lift twelve 30-watt tubular lamps are used; the system is exceedingly effective. Sources of light are completely screened from view and the interior of the lift appears "full of light." In the Main Hall there is also a specially designed luminous clock.

Stairway Lighting.

The lighting of the stairways (see Fig. 2) is also original and well conceived. It will be seen that the arrangement provides both vertical and horizontal lighting surfaces, both of mild luminosity. The stairs are excellently lit and there is absolutely nothing to distract the eye or cause glare.

General Office Lighting.

The general lighting scheme, widely used throughout the building, is illustrated in Fig 3. As already mentioned this utilises 200-watt lamps in 14-in. diameter three-ply flashed opal glass spheres (internally frosted bulbs are being substituted for clear ones in order to eliminate the shadow of the filament on the glass surface and give a completely uniform effect) which give even brightness of the ceiling. Partly owing to the special scheme of ventilation, which admits dust-free air from inlets near the ceiling, the maintenance of these lamps has proved an easy problem. They are rarely touched, yet the illumination has not sensibly diminished. In the Special Committee Room original lighting by means of "luminous beams" of glass enclosing twenty-five 25-watt internally frosted lamps run from end to end of the room. Twenty 15-watt lamps on 8-in. centres are used in each bay.

The lighting of the buffet bar, which may be viewed on leaving the building by the east entrance, is also lighted (Fig. 6) by a series of troughs carrying thirty-six 25-watt lamps at 6-in. centres.

The Consulting Engineers for the electrical work were Lever Brothers, Ltd., Electrical Dept., under the management of Mr. R. G. Devey.

The Architects were Mr. J. L. Simpson, Director of Unilever, Ltd., in consultation with Sir John Burnet, Tait and Lorne.

The Electrical Contractors were Messrs Troughton and Young, Ltd.

Amongst those responsible for the fittings were Messrs Troughton and Young, Ltd., and Messrs. Osler and Faraday, Ltd.

The General Electric Co., Ltd., were responsible for the floodlighting of the front of the building.

(The lighting of the premises of Glyn Mills and Co., Lombard-street, visited by members of the Illuminating Engineering Society on the same evening, will be described and illustrated in our next number.)

Figure 5. The special Committee Room (Fourth Floor). Lighting is furnished by "luminous beams" running the entire length of the room.

Figure 6. The Buffet Bar. A good example of trough lighting.

TECHNICAL SECTION

COMPRISING

Transactions of The Illuminating Engineering Society and Special Articles

The Illuminating Engineering Society is not, as a body, responsible for the opinions expressed by individual authors or speakers.

The Illuminating Engineering Society

Notes on Recent Meetings and Events

A MEETING of the Illuminating Engineering Society took place in the Lecture Theatre of the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1), on Tuesday, April 10. Members assembled for light refreshments at 6.30 p.m., and the chair was taken by the President (MR. C. W. SULLY) at 7 p.m.

The Minutes of the last meeting having been taken as read, the HON. SECRETARY read out the names of applicants for membership, which is appended. The names of those presented at the last meeting, on March 13 (ILLUMINATING ENGINEER, April, 1934, p. 117), were read again, and these gentlemen were formally declared members of the Society.

The PRESIDENT then called upon MR. JUSTUS ECK to present his paper on "The Art and Practice of Garden Illumination." The paper reviewed in a comprehensive way methods of illuminating flowers and foliage at night, both by gas and electric lighting, and was illustrated by numerous lantern slides, some executed in colour. The paper was heard with great interest by an audience which included representatives of the Royal Horticultural Society, the Association of Superintendents of Parks and Botanic Gardens and other bodies interested in the subject.

In the subsequent discussion, MRS. C. C. PATERSON, MR. W. H. JOHNS, MR. BORLASE MATTHEWS, MR. H. CHEVALIER, MR. R. O. SUTHERLAND, and MR. C. C. PATERSON took part.

Mr. Eck's paper and the ensuing discussion will appear in a forthcoming issue.

Applicants for Membership.

Corporate Members:—

Burdett, G. H.........The North Metropolitan Electric Supply Co., Ltd., 48, Lion Road, Lower Edmonton, LONDON, N.9.

Chevalier, H.............40, Kenmure Mansions, Pitshanger Lane, Ealing, LONDON, W.5.

McDermott, L. H......(The National Physical Laboratory); 19, Pine Gardens, Surbiton, SURREY.

Perkins, W. H..........(Messrs. L. G. Hawkins and Co., Ltd.); 44, Wharfedale Gardens, Thornton Heath, SURREY.

Preston, J. S............(The National Physical Laboratory); "Mendip," Burton's Road, Hampton Hill, MIDDLESEX.

Country Members:—

Arnott, F. G.........(Messrs The Simplex Electric, Ltd.); "Crofton," Stamford Road, Rowden, CHESHIRE.

Bolt, F. D................Electrical Engineer, 11, Harley Street, Leigh-on-Sea, ESSEX.

Chancellor, H. E.......(Messrs. W. Parkinson and Co., Ltd.); 171, Burton Road, West Didsbury, MANCHESTER.

Nettleton, J. D..........Illuminating Engineer, 49, Cavendish Road, SALFORD 7.

Affiliated Students:—

Brett, F. J...............24, Chatham Grove, Withington, MANCHESTER.

Lovell, C. F.............16, Parkham Street, Battersea, LONDON, S.W.11.

Munns, R. M...........Flat No. 7, 55, Elystan Street, Chelsea, LONDON, S.W.3.

Winfield, N. L.........."Holmleigh," Larkfield, Rawden, Nr. LEEDS.

Winstanley, G..........Chaseley, Oatlands Drive, Walton-on-Thames, SURREY.

Wray, J. B...............Milsey Bank, Holly Park, Crouch Hill, LONDON, N.4.

Forthcoming Events

The **Annual General Meeting** will take place on **Tuesday, May 8th,** in the Lecture Theatre of the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1). After formal business has been transacted **an address reviewing progress in illumination in the United States** will be delivered by MR. SAMUEL G. HIBBEN (Director of Lighting for the Westinghouse Co., New York City). **6.30 p.m.**

(See also special notice on p. 157.)

By the courtesy of the London Power Company, Ltd., a **Second Visit** to the new **Battersea Power Station** has been arranged to take place on **Tuesday, May 29th.** The number of the party is necessarily limited, and its constitution will again be determined by the drawing of lots. Preference will be given to those now applying who were unsuccessful in the ballot on the occasion of the first visit in November last.

Applications should reach the Hon. Secretary not later than **May 14th. 2.30 p.m.**

Heterochromatic Photometry

with Particular Reference to the Photometry of Luminous Discharge Tubes*

By H. Buckley
(of the National Physical Laboratory)

(Continued from page 122, April, 1934)

VII. PHOTOMETRY OF LUMINOUS DISCHARGE TUBES.

The previous work shows that the transmissions of coloured filters can be satisfactorily determined by both the flicker photometer method and by the method of calculation, with the proviso that for blue green glasses the results are a little low by the flicker photometer.

If one has a series of these glasses, each of these glasses can be used in conjunction with light sources of known candle-power and colour temperature to give sources of known candle-power of very different colours. These can then be used as standards for the determination of the candle-power of other coloured sources. With sources of light having a continuous distribution of energy in their spectra it will usually be the case that close identity of colour will mean close identity of energy distribution, so that the photometric procedure involved will be photometry of small colour and energy difference. We should expect in these cases that the equality of brightness method would be satisfactory, and no Purkinje or yellow spot effects would give trouble, as both sources would be affected in practically the same way.

In the case of the newly developed gaseous discharge tubes, the spectrum of the emitted light is discontinuously distributed throughout the spectrum in lines, so that even if a combination of a gas-filled lamp and a coloured filter gives light of the same colour as that of the discharge tube, there may be a very great difference in the distribution of energy in the spectra of the two sources. The fact that the two sources match in colour will make the photometric comparison an easy one for each observer, but the inherent differences between observers and the difference in energy distribution of the two sources may still make the results obtained dependent on the observer and also on the field and brightness conditions.

The object of the work now to be presented was to investigate the limitations, if any, of the method of photometry in which colour differences do not exist (or are small), and at the same time the energy distributions responsible for the colour match are considerably different.

The photometry of gaseous discharge lamps has been discussed by Paterson (11), Fabry, Roux and Perrin (12), Yamauti (13) and Dziobek and Reeb (14). Suitable filters to obtain a colour match with neon and sodium lamps have been described by these workers.

Four types of discharge tube were used, as follows:—

(1) Neon. Hot cathode type. 2 amps.
(2) Sodium. Hot cathode type. 2 amps.
(3) Mercury. Street-lighting type. 400 watts.
(4) Mercury. Hot cathode type. 2 amps.

* Paper read at the meeting of the Illuminating Engineering Society, held at the Institution of Mechanical Engineers, Storey's Gate, St. James's Park, London, S.W.1, at 6.30 p.m., on Tuesday, February 20, 1934.

Of the two mercury tubes the hot cathode type was considerably bluer in colour than the other, which is now becoming extensively used in street-lighting installations.

The first procedure was to obtain filters which, in combination with a gas-filled tungsten lamp operating at a colour temperature of 2360°, gave light of the same colour as that given by the tubes. After considerable search, four glasses were found. Their transmissions throughout the spectrum are shown in fig 6 and data about them in Table II. below:

TABLE II.

Filter	Used with	Integral transmission 2360°	Spread large field	Spread small field
CF 47	Neon tube	28.1%	4%	5%*
CF 51	Sodium tube	21.2	4	7
CF 49	Mercury (street-lighting tube)	23.6	8	6**
CF 50	Mercury (tube)	8.9	7	7**

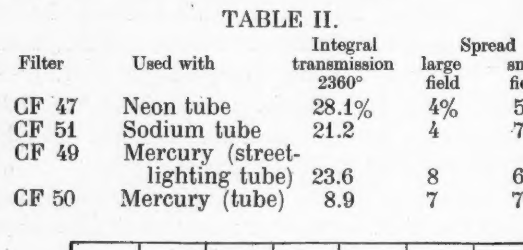

Figure 6. Spectral Transmission of Filters used in Measurements on Luminous Discharge Tubes.

* Excluding one observer.
** Excluding two observers, one of whom obtained very high values and one who obtained very low values.

Filter CF.51 consisted of two glasses cemented together. CF.49 was a thick piece of artificial daylight glass. None of the filters gave a perfect colour match, except the filter CF.47, used with the neon tubes. It is unlikely when the energy distributions differ that what appears to be a colour match to one observer will also appear to be a colour match to another. In all cases, however, some of the observers expressed the opinion that the colour match obtained was quite good, and all agreed that it was satisfactory and made setting to photometric balance easy. The total spread in the candle-powers obtained by the ten observers for each of the tubes are shown in the end two columns of Table II. The spreads which occur when no colour filter is used are, of course, very much greater than these.

The candle-power of a six-inch length of each of the hot cathode lamps, and of the whole tube in the case of the street lighting lamp, was determined. For each tube the candle-power was determined in eight ways as follows:

Photometer	Method	Colour difference	Field size	Field brightness
Guild	F	Full	2°	25 m.c.
	F	None	2°	25 m.c.
	E. of B.	None	2°	25 m.c.
	E. of B.	Full	2°	25 m.c.
Lummer Brodhun	E. of B.	Full	8°	15 m.c.
	E. of B.	None	8°	15 m.c.
	E. of B.	None	2°	15 m.c.
	E. of B.	Full	2°	15 m.c.

The tube was situated at one end of the photometer bench with the comparison lamp operating at 2360° at the other end. The coloured filter when used was placed on the comparison lamp side. The tube was then replaced by a standard lamp operating at 2360° and compared with the comparison lamp without the coloured filter.

A complete set of observations occupied two days. The first afternoon was spent in making the comparison with the standard by means of the Guild photometer operated as a flicker photometer, and also as an equality of brightness photometer.

The morning of the second day was spent in comparing the tube with the comparison lamp by means of the flicker photometer in four ways. The afternoon was similarly spent with the Lummer Brodhun photometer, and in the morning of the third day the standard lamp was compared with the comparison lamp by means of the Lummer Brodhun photometer, using a large field and also a small field. Ten observers took part in the tests. The discharge tube was operated continuously on the day on which measurements were made. Check readings at the beginnings and ends of the morning and afternoon's work gave very good agreement as a rule, and there is no reason to suspect that the candle-power of any of the tubes during the morning measurements was more than 3 per cent. different from its candle-power during the afternoon measurements. The comparison of the results obtained during a morning or an afternoon are independent of any small variations in the tubes as each observer took his four sets of observations with another observer during a period which was not more than 20 minutes, and the order of the observers apart from the first two was a purely random one.

Neon Lamp, Hot Cathode Type.

The following are the results for the neon tube in terms of the horizontal candle-power of a six-inch length of the tube operated at a constant direct current of 2.0 amperes.

The results of the measurements with no colour difference show what can be considered to be perfect agreement. The colour match was extremely good, and in view of the fact that with the neon lamp practically all the light is given out by a large number of lines at the end of the spectrum, and that with the combined filter and lamp the light is continuously distributed over the same region of the spectrum, there is a close practical identity of energy distribution. In this case the photometric comparison would be one carried out in practically the best conditions and should be independent of the observer. In particular there is no field size effect as a consequence.

No Colour Difference.		*With Full Colour Difference.*	
Flicker small field (G Phot)	46.9	Flicker small field (G Phot)	48.5
Eq. of B small field (G Phot)	47.0	Eq. of B small field (G Phot)	49.0
Eq. of B small field (LB Phot)	47.3	Eq. of B small field (LB Phot)	48.7
Eq. of B large field (LB Phot)	47.3	Eq. of B large field (LB Phot)	42.0

The measurements with full colour difference are also in good agreement with those obtained with no colour difference. The flicker results are a little high as, perhaps, might be expected from the curve in fig. 4. The low result for the large field, if one can trust measurements with a large colour difference, is also what one would expect from the large field size, i.e., the blue is over weighted in the white light source and the red under rated.

Sodium Lamp, Hot Cathode Type.

The following are the results for the sodium tube in terms of the candle-power of a six-inch length of the tube operated at a constant direct current of 2.0 amperes:—

No Colour Difference.		*Full Colour Difference.*	
Flicker small field (G Phot)	224	Flicker small field (G Phot)	231
Eq. of B small field (G Phot)	226	Eq. of B small field (G Phot)	228
Eq. of B small field (LB Phot)	234	Eq. of B small field (LB Phot)	242
Eq. of B large field (LB Phot)	232	Eq. of B large field (LB Phot)	223

Here again the measurements with no colour difference are in fairly satisfactory agreement. Those carried out on the Lummer Brodhun photometer were a little higher than those carried out on the Guild photometer. This may be due to experimental error or a small change in the tube as between morning and afternoon measurements. There appears to be no field size effect in spite of the difference in energy distribution of the two sources compared. This is probably because the luminosity of the combined tungsten lamp and filter is practically equally distributed on each side of the sodium line, and that in consequence the field size effects on each source should be equal and no residual field size effect is experienced.

The measurements with the full colour difference show very good agreement. The flicker value is a little higher than the equality of brightness value obtained with no colour difference on the same photometer. The value obtained with the large field is low, and if real agrees with what one would expect.

Mercury Vapour Street Lighting Lamp.

Several complete sets of measurements were carried out on the mercury vapour street lighting lamp. The lamp was operated at 400 watts, and the values given are the horizontal candle-power of the whole lamp. The results of three of these sets, together with the means, are given on the next page.

The results by all the methods, including those on which the full colour difference was experienced, cover a range, if we consider the average values in each case, of about 6 per cent. The consistency of the results by each method, however, indicates that the differences shown though small are real and systematic.

No Colour Difference				
Method	Horizontal Candle power			
	1	2	3	Mean
Flicker small field (G. Phot.)	1205	1210	1205	1207
Eq. of B. small field (G. Phot.)	1245	1235	1238	1239
Eq. of B. small field (LB. Phot.)	1265	1254	1230	1250
Eq. of B. large field (LB. Phot.)	1185	1169	1156	1170

Full Colour Difference				
Method	Horizontal Candle Power			
	1	2	3	Mean
Flicker small field (G. Phot.)	1200	1176	1196	1190
Eq. of B. small field (G. Phot.)	1225	1266	1246	1246
Eq. of B. small field (LB. Phot.)	1230	1210	1190	1210
Eq. of B. large field (LB. Phot.)	1230	1217	1220	1222

In considering the results obtained under colour match conditions, the two results obtained by the equality of brightness small field method by means of the Guild and Lummer Brodhun photometer are seen to be practically identical, viz., 1239 and 1250 with a mean value of 1245. These values have the greatest claim to be regarded as the correct values as they were obtained with the small field at an illumination of 25 mc., approximately the same field size and brightness conditions as those to which the standard visibility data apply.

The effect of field size is shown in the results obtained by the Lummer Brodhun photometer, in which a value of 1250 obtained with a small field becomes 1170 when the large field was used, a difference of about 6 per cent. This implies that the mercury lamp behaves as if it emitted a redder light than the light from the combined lamp and filter whose effective wavelength was 0.553μ. The light from the mercury lamp largely consists of yellow light of wavelength 0.587μ combined with an amount of blue light which, although of low luminosity, has a pronounced effect in producing colour. Although there was an approximate colour match (the mercury light being slightly redder), from the point of view of energy the mercury light may be considerably "redder" than the colour matching light.

If we now consider the two values obtained by means of the flicker photometer at colour match and the small field equality of brightness also at colour match, we find that the former is consistently lower than the latter, i.e., 1,207, as against 1,245. We should expect the results to be the same since the flicker method merely involves two sources of the same colour. The energy distributions are not the same, and the difference is in the direction we should expect from fig. 4, if the mercury light were bluer in the energy sense than the light which colour matched it. This is not consistent with the argument which tended to explain the field size effect. The difference in the values is small, but appears to be real, and no question of the value given to the colour filter comes in as the filter was used in each case.

The flicker method with full colour difference is low, viz., 1,190, compared with 1,245, the small field equality of brightness value. From fig. 4 we should expect the flicker method to give slightly lower values for light which colour matches a lamp and filter of effective wavelength 0.553μ.

The three determinations with full colour difference by the equality of brightness method are in surprisingly good agreement, and there is no evidence of a field-size effect on the Lummer Brodhun photometer. This would be explained if there were a better energy match with full colour difference than at colour match.

The differences which are being discussed are really small, so that it is not surprising that in attempting to account for them there should be certain discrepancies in the assumptions that have to be made.

The most important results are, however, that the flicker method with full colour difference gives low values by about 4 per cent., and that the equality of brightness method with no colour difference and large field also gives definitely low values by about 6 per cent. If the best result possible with our present knowledge is desired, the small field value should be taken.

In order to check the values obtained above, using filter CF.49, filter CF.10 was used in some measurements. The values obtained checked off satisfactorily with those obtained by means of CF.49, being about 1 per cent. lower.

MERCURY VAPOUR LAMP, HOT CATHODE TYPE.

The following are the results for the hot cathode mercury vapour lamp, in terms of the candle-power of a six-inch length of the tube operated at a constant direct current of 2.0 amperes.

No Colour Difference.		*Full Colour Difference.*	
Flicker small field (G Phot)	21.6	Flicker small field (G Phot)	21.4
Eq. of B small field (G Phot)	22.1	Eq. of B small field (G Phot)	22.1
Eq. of B small field (LB Phot)	22.6	Eq. of B small field (LB Phot)	21.6
Eq. of B large field (LB Phot)	20.7	Eq. of B large field (LB Phot)	23.0

The general character and variation of these results are almost identical with those of the last results, so that practically the same remarks can be made about them. The only difference of significance is that there also appears to be a field size effect with full colour difference shown by the results obtained on the Lummer Brodhun photometer. The high value of 23.0 compares with 21.6 is what one would expect in these circumstances.

The general conclusions which may be drawn from these experiments with luminous discharge tubes are:

(1) The use of coloured filters of calculated transmission factors to produce a colour match provides a satisfactory method of photometry for all the tubes investigated.

(2) The use of such filters tends to make all observers get the same result for the neon and sodium tubes. In the case of the mercury lamps, where with colour match there is considerable energy difference, the use of filter reduces the spread of the observers considerably, but there is still a considerable spread in their results.

(3) The results obtained by means of the large field are lower than those obtained by means of a small field in the measurement of mercury lamps.

(4) The small field should be used. Alternatively, if the small and large field give different results, the small field should be used.

VIII. PURKINJE EFFECT.

As the measurements on the mercury lamps showed the existence of the yellow spot effect or field size effect, even when there was an approximate colour match in the photometric field, it is to be expected that a Purkinje effect will also be exhibited for the larger field sizes. Experiments were carried out to test this. The Lummer Brodhun photometer with large field size was used, and equal sectors were placed on opposite sides of the photometer. If the photometer is balanced when large transmission sectors are used on each side, then, if there is no Purkinje effect, the balance should not be disturbed if the sectors are replaced by equal low transmission sectors. It was found that the balance did alter when the transmissions of the sector were such as to give effective illuminations on the screen of the photometer of less

than 3 m.c. At 0.3 m.c. the effect was about 10 to 20 per cent., varying with the observer. It was such that the candle-power of the lamp deduced from measurements at low illuminations would be lower than those deduced from measurements at high illuminations. This is in the same direction which one would expect from the field size effect, i.e., the lamp behaves as if it were redder than the combined comparison lamp and coloured filter, and decrease of illumination weights the bluer source.

The fact that the balance changes as the illumination decreases means that the relative visibility curve of the observer changes as the illumination decreases. It changes, of course, for each source, so that an observed Purkinje effect is really a differential effect. If the two brightnesses compared have the same energy distribution, the change in visibility affects both brightnesses to the same extent, and no Purkinje effect is observed.

Similar measurements were made with the small 2° field, and no appreciable Purkinje effect was observed down to an effective illumination of 0.3 m.c., the lowest illumination used.

These results have an obvious bearing on the measurement of low illuminations, particularly in street lighting with portable photometers. The object of using coloured filters of calculated transmission is to produce a colour match (an energy match if possible), so that any observer should obtain the same results as would be obtained by the hypothetical standard observer (defined by the visibility data), who suffers from no Purkinje effects, since the visibility data refer to foveal vision. So long as no Purkinje effect is present, the observer obtains approximately the same results as the hypothetical observer. If, however, there is a Purkinje effect, the result obtained is not that which would be obtained by the hypothetical observer, nor is it that which would, in general, be obtained by the observer himself had he not used the colour filter.

With the large field size the visibility of the observer varies continuously as the level of illumination decreases below about 6 m.c., so that at every illumination level below this he is a different unknown observer. Guild [15] has dealt with the philosophical aspects of this problem as affecting the existence of a photometric scale, in which brightnesses equal to the same brightness are equal to each other, and in which the whole is equal to the sum of its parts. As photometrists, however, we may be content to obtain the same results as the standard observer possessing an eye defined by the internationally agreed visibility curve, which is the same at all brightness levels.

With the small field this can be done at any level of illumination at which there is no Purkinje effect. The lower limit of this for real observers as distinct from hypothetical observers is not known, but is probably below 0.1 m.c. Alternatively, it is possible for an observer to obtain the results which would be obtained by the hypothetical observer at low levels of illumination if he directly calibrates his portable photometer against actual illuminations covering the range of illuminations which are to be measured. If the calibration agrees with that deduced from higher illuminations, then there is no Purkinje effect. If it does not, then by using his own calibration he should get the same results as the hypothetical observer.

The fact of the existence of the Purkinje effect is in itself a strong argument for using the small field in those circumstances where the Purkinje effect may play a part.

At extremely low levels of illumination, where it is possible that even with the small field size the relative visibility of real observers may change with the brightness level, the question of the meaning, if any, of photometric measurements is another problem which will have to be considered by photometrists.

IX. CONCLUSIONS.

The results of the measurements described in this paper show:—

(1) the flicker photometer gives results in agreement with those obtained by calculation except at the blue end of the spectrum, where it seems to give systematically results slightly less than are given by calculation;

(2) the equality of brightness photometer with small field gave unsatisfactory results in the measurement of coloured lights using the full colour difference. It has not yet been established that the results obtained by calculation either agree or do not agree with those obtained by the equality of brightness small field photometer;

(3) the photometry of discharge tubes of the neon and sodium vapour type can be satisfactorily carried out by the use of coloured filters of calculated transmission. The transmission curves of suitable filters are given. With these filters the results are independent of the method of photometry whether flicker or equality of brightness with large or small fields if the illumination of the photometer screen is 25 m.c.

(4) the photometry of discharge tubes of the mercury vapour type can be satisfactorily carried out by the use of coloured filters of calculated transmission. The transmission curves of suitable filters are given. With these filters the results are not independent of the method of photometry employed, even if the illumination of the photometer screen is 25 m.c. The small field equality of brightness method is recommended;

(5) the use of coloured filters to produce an approximate colour match reduces the spread of the observers very much in the case of filters to colour match neon and sodium lamps. In the case of mercury vapour lamps a colour match is still accompanied by a considerable energy difference. The spread of the observers is reduced, but is still considerable, and several observers are necessary in order to obtain satisfactory results;

(6) The Purkinje effect in the photometry of mercury vapour tubes by means of coloured filters is investigated. The Purkinje effect is found to be negligible if the illumination on the photometer screen is greater than about 3 m.c.

X. ACKNOWLEDGMENTS.

The results presented in this paper represent a considerable amount of work which, apart from that on the luminous discharge tubes, has been spread over a number of years. To do it at all has required the willing co-operation of many of the author's colleagues; co-operation given very often at inconvenient times as regards their other work. The author greatly appreciates the assistance given by his colleagues, either in acting as observers or in taking charge of certain portions of the work. In particular, he is indebted to the very careful work of Mr. F. J. C. Brookes and Mr. F. M. Hale in determining the spectral transmissions of the various filters and for the numerous rather tedious spectrophotometric calculations which have had to be made. He is also particularly indebted to Mr. W. Barnett in the work of the luminous discharge tubes which were largely carried out under his supervision, and the author has had the benefit of discussing with him the numerous photometric problems which have arisen from time to time.

Cordial thanks are also due to Mr. C. C. Paterson, the Director of the Research Laboratories of the General Electric Company, Ltd., Wembley, who very kindly lent the luminous discharge tubes used in the work, and to Mr. G. T. Winch, of the same laboratories, who gave much useful advice in connection with the operation of the tubes.

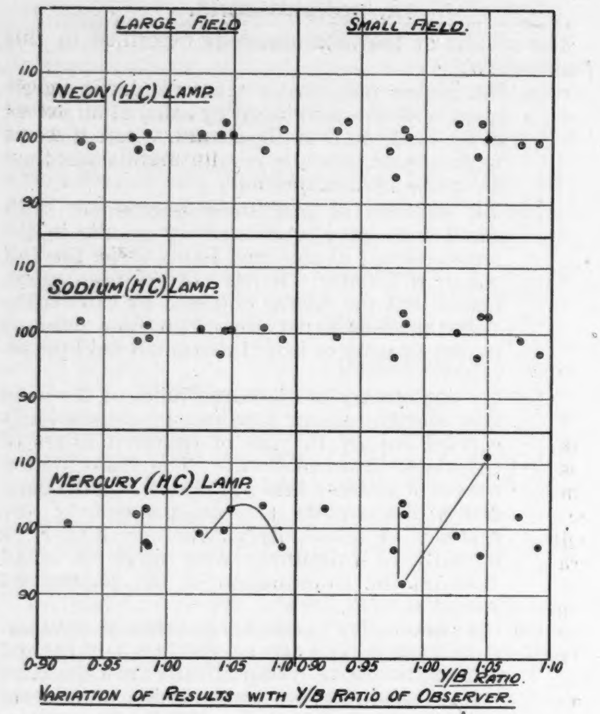

Figure 7.

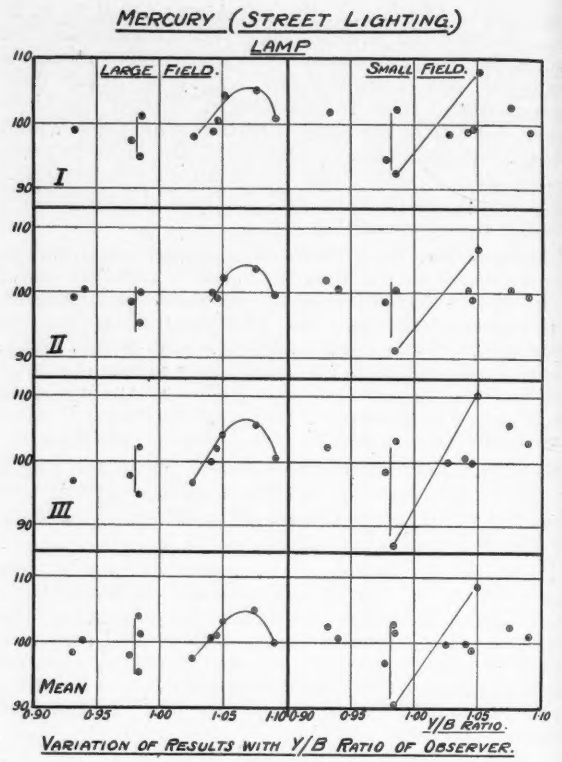

Figure 8.

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APPENDIX.

The figures 7 and 8 show the distribution of the results obtained in the measurement of the discharge lamps by means of the Lummer Brodhun photometer employing the large and the small field. They are plotted against the Y/B ratios of the observers and are calculated so that the mean in each case is 100.

For the neon and sodium tubes the spreads of the results in fig. 7 are very satisfactory. In the case of the mercury hot cathode lamp the spread is becoming rather large and it appears that the Y/B ratio method of obtaining the value which would be obtained by the average eye is breaking down. The spread with the small field for observers whose Y/B ratio is about 0.98 shows that the differences between observers do not correlate well with their Y/B ratios. Similar results are shown in fig. 8 for the mercury street lighting lamp. The first three sets are the results of three separate determinations. The fourth is the mean of four determinations in which the fourth gave very similar results to those given by the three illustrated.

The distribution of the points is strikingly similar in each case and shows that the deviations from the best straight line through them are not due to experimental errors. They must, therefore, be due to inherent differences in observers' visual characteristics which are not eliminated by the use of the Y/B ratio method of deducing the result which would be obtained by an observer possessing the average eye.

DISCUSSION.

Mr. C. C. Paterson said that the chief contribution to the discussion from the photometrists at Wembley would be made by Mr. G. T. Winch. He (Mr. Paterson) would confine his remarks to congratulating the author and the N.P.L. on the smartness shown in tackling the work of the photometry of the new gaseous electric light sources. It was very valuable to have the experimental work described by the author, and particularly to have the hope that the N.P.L. might now be ready to give values of candle power for these sources. From reading the paper the impression might be gained that, given a proper photometric equipment, an accuracy of a few per cent. might be expected, but the reader must remember that the N.P.L. photometrists are very experienced and have some of the best facilities in the world. Mr. Winch would confirm much of the author's work when carried out under the same sort of conditions. The measurement of the lamps under more ordinary conditions and the measurement under street lighting conditions were liable to very considerable errors which it would be unwise to minimise.

Mr. G. T. Winch said that before considering results in detail he would like to ask whether it could

be stated whether in cases where equality of brightness photometry was mentioned, a contrast type of field was used or no.

He thought it desirable to emphasise the foundations of the visibility data. The use of calculated transmission values for filters involves all the errors involved in determining the visibility data besides any introduced in determining the transmission of the filters. For this reason he would hesitate to accept results based on equality of brightness tests using filters of calculated transmission, to the exclusion of results obtained directly by the flicker method. This had a bearing on the value ascribed to the high pressure mercury lamp in the paper. He would be inclined to assess a lower value than 1245, in view of the two flicker results of 1207 and 1190, and would prefer an average result based on both methods—which would be 1217.

He had found that the inconsistency of observers, discussed in the paper, was very marked when equality of brightness methods were used. A final comparison between different methods of photometry should not, however, be made until the methods which were found to give the greatest variations were repeated many times. This would not reduce the spread in any observer's results, but would enable the result for a Y/B ratio of unity to be obtained with greater precision more comparable with that attainable by the flicker method. This view might have a considerable effect on the final value assigned to a source of coloured light.

Observation of the data included in Fig. 4 suggested that results obtained by him (Mr. Winch) and his colleagues most resembled those given by "L.R.L." and did not show the fall towards the blue end, recorded by Mr. Buckley.

Mr. Winch said that during the last two years he and his colleagues had also done a considerable amount of work on this subject, and showed some lantern slides which he had prepared illustrating the variations in the observations of fifteen observers when making photometric measurements on neon, sodium, and high pressure mercury gas discharge lamps, using a Guild flicker photometer, a Lummer Brodhun, contrast type 6 degree field, and an equality of brightness, 2 degree field, the field illuminations being in every case 25 M.C. or more.

These diagrams showed the individual results plotted against the observer's Y/B ratios and the degree of consistency in the results of the three types of photometer head used when observing with the full colour difference was in the following order:—

(1) Guild flicker photometer.
(2) Lummer Brodhun, contrasts type 6 degree field.
(3) Equality of brightness, 2 degree field.

He showed that there were consistent differences between the results obtained with the different photometer heads when making measurements with the full colour difference between the gas discharge lamps and the tungsten comparison lamp. However, the unity Y/B values obtained with the Guild flicker photometer were shown to be in close agreement with results obtained when using a Lummer Brodhun contrast photometer, 6 degree field, and suitably chosen colour filters calibrated for transmission by the spectro-photometric method. In these cases there was very little colour difference between the two sides of the photometer field.

Tabulated results of the unity Y/B values obtained by these methods were shown in general to agree with Mr. Buckley's results. Mr. Winch hoped that shortly this work would be published, and concluded by suggesting the middle course of taking the average of results obtained from the two methods, namely:—

(1) Direct measurement by flicker photometer with a field of 2° and 25 m.-c illumination.
(2) Equality of brightness (contrast field) under conditions of approximate colour-match, using filters, the transmission of which are determined from special data.

Professor J. T. MacGregor-Morris expressed his admiration of the great amount of work done by Mr. Buckley and his colleagues. In considering heterochromatic photometry it was necessary to draw a clear distinction between laboratory work and actual measurements in the street. In the latter case, one had to make measurements at low illuminations, and in addition one usually worked with a large field. Now Mr. Buckley had shown just the opposite of these conditions was the best for accurate laboratory work. He recalled that Mr. A. P. Trotter many years ago had developed a portable photometer with an exceptionally large field with which very good results were obtained. In a later instrument, otherwise similar, the field of view had been reduced, and it was found that one could not attain the same precision. A return to the larger field, however, set the matter right.

The next point was one on which he would like to ask for more information. How do equality of brightness or flicker results compare with those obtained by photo-electric methods? What kind of precision could be obtained with photo-electric cells and with photovoltaic cells? As we all agree that there are many grave difficulties in heterochromatic photometry, why not eliminate them by adopting methods based on the comparison of two sources of the same kind? For example, in making measurements on street lamps, one might use a standard of the same type. Possibly it is an impractical idea, but the suggestion is this—to use a hand truck carrying a petrol electric set supplying current to a gaseous discharge lamp giving substantially the same spectrum as that of the lamp under test. He believed that it was true if two lamps of the same type were compared the precision of the measurement could easily be brought to within two per cent.

Mr. J. S. Preston said he had read the paper, which contained an excellent survey of the subject, with great interest. He was struck by the large amount of work involved, which was specially interesting because of the information to be deduced from it concerning the behaviour of the eye. Mr. McDermott and he at the National Physical Laboratory had been interested in the problem of finding a photo-electric "eye" which would give the same results as the average human eye. They had succeeded in devising a photocell-filter combination which had been used *without modification* for neon, sodium, and mercury tubes, and in each case had given, on a single photoelectric comparison, a candle-power value within the range of the visual results by the no colour difference methods described in the present paper. The combination consisted of a rubidium-on-silver thin film vacuum cell, with an aqueous solution of cupric chloride, cobalt ammonium sulphate, and potassium dichromate as colour corrective filter. The appropriate concentrations of these solutions were determined by calibration of the photometer with coloured glasses of known transmission.

In respect to the paper, however, there were two points he would like to ask Mr. Buckley. There was the question as to why the results with the flicker photometer showed a certain falling off. Could this be due to discoloration of the magnesium oxide which might have become slightly yellow? Secondly, since the visual photometry of sources giving line spectra appears to be a difficult and perhaps lengthy procedure, have we not reached a stage where direct physical measurements of radiation throughout the spectrum, coupled with the use of standard luminosity data, might not result in a saving of time and an improvement in accuracy?

Mr. P. D. Oakley put the following queries to the author:—

(1) Assuming that the 400-watt street lighting lamp was run on alternating current, had this any apparent effect on the flicker measurements?

(2) The author had recommended the use of coloured filters to produce an approximate colour match, and

the filters which he used for this purpose were apparently made up specially. Could he state whether there were any commercial screens having the right transmission?

(3) What was the probable error of a single determination (say the mean of 10 readings) by one observer using the equality of brightness method with a large field and full colour difference, but making allowance for the Y/B ratio of the observer?

(4) Had any measurements of luminous flux on the mercury vapour lamps been made and what would be the effect on such measurements of having slightly selective paint on the surface of the sphere?

Continuing, Mr. Oakley said that he had been interested in the author's observations on the difference between colour match and colour identity. Recognition of this difference enabled him to interpret some of the discrepancies in the results obtained by different methods when considering the photometry of mercury vapour lamps. He was left, however, with one unresolved anomaly, and presumably some unknown factor enters into the problem, as the energy value of the discharge lamp could hardly be at one and the same time both redder and bluer than the visual value when compared with filtered tungsten light.

The difference between apparent colour match and colour identity was, however, of significance in other ways. The colour rendering of objects depended on whether or not the spectrum contained light of some wave length in each region, none being completely absent. In other words, a representative if not a continuous spectrum was required. The apparent hue of the light depended on whether or not some components were in excess. Now a recently developed discharge lamp which gave greatly improved colour rendering of objects, having a much more representative spectrum than the plain mercury lamp, yet had an apparent blue colour, somewhat resembling the blue of a clear sky, which was very difficult to match in the photometer head against a tungsten filament comparison lamp.

It was evident that the energy-balance had been shifted towards the red end as compared with an uncorrected mercury lamp, yet the apparent colour had been shifted towards the blue end. This would seem to imply that measurements by the equality of brightness method, using a large field, would be subject to even greater errors than the results given in the paper. The results obtained by using a screen to give no colour difference were even worse than those obtained with the full colour difference, but both results were on the low side.

He would be glad if the author would confirm that this deduction from his conclusions was correct.

Dr. E. H. Rayner likewise wished to congratulate Mr. Buckley on the paper which could not have been written without an enormous amount of study beforehand. The subject was well known to be full of difficulties. With regard to the tables Mr. Buckley had shown he wondered if he could be really sure that the results given by ten observers represented the results which would be obtained by the average eye.

Mr. L. J. Davies wished to congratulate the author. He was speaking from the point of view of a manufacturer of discharge lamps who desired standardisation of photometric methods. In the laboratories new lamps were being developed as well as modifications in existing lamps. This made it all the more difficult to find a " yardstick " for luminous output. He would like to ask Mr. Buckley if there were any standard filters available which might be used to overcome the colour difficulty. When it was known how to measure accurately, something would have to be done with a " seeing " photometer. With regard to Professor MacGregor-Morris's question in regard to street lighting he would like to say that they were using the photoelectric cell method for this purpose. It would probably not be long before these lamps would be used quite generally in factories, and he would like to have Mr. Buckley's views as to the photometric methods by which their utilities in this direction should be assessed.

Mr. J. M. Waldram said that the thanks of street lighting engineers were specially due to Mr. Buckley for giving them an indication of the very large errors which were liable to occur in the conditions of street lighting photometry, particularly when dealing with discharge lamps. Mr. Buckley had dealt with laboratory measurements; measurements of illumination in the street were, however, necessary and often bore considerable commercial responsibility.

Not all the devices available in the laboratory were available for portable photometers. With A.C. discharge sources a flicker photometer could not be used, and probably most commercial instruments would have to rely upon the small field equality of brightness principle, using a filter on the comparison side. At the Research Laboratories of the G.E.C. the contrast type 6° Lummer-Brodhun head has for a long time been employed, and in the photometry of discharge lamps observers were used whose Y/B ratios were known. By employing the correction appropriate to each observer, obtained from Mr. Winch's curve, results in close agreement with laboratory results had been obtained. He was interested to note that in Mr. Buckley's results shown on a slide the Y/B curve for the high-pressure mercury discharge lamp had no definite slope, whereas Mr. Winch's results showed a definite slope which had been successfully used for correction. He asked whether the difference were due to the fact that Mr. Buckley had used an equality-of-brightness field, whereas Mr. Winch had used a contrast field. If this were the cause of the difference it had a bearing upon photometer design, for the contrast type field was expensive and could not well be used except in costly instruments.

The necessity, in practical work, for the use of filters had several implications. Provision would have to be made in photometers for the insertion of colour filters on the comparison side; in some types this is not easy, especially as the filter may have to be changed or withdrawn often. In the illumination photometer recently designed at the Research Laboratories and exhibited before the Society in November last this provision has been made; ordinary 2 inch square filters of the Wratten type could be inserted. Filters for the photometry of discharge lamps would have to be produced and properly calibrated; unless their production were undertaken soon, chaotic results would be obtained in street lighting work. Furthermore, there seemed to him to be room for the standardising of lamps for portable illumination photometers. Such lamps were difficult to make, and it was becoming urgent that they should be available in a standard rating; bulb shape and size; resistance; dimensions; cap; and particularly, if filters were to be used, of known colour temperature.

Mr. E. L. Damant referred to the question of one speaker that for slight changes in discharge lamps a new filter would have to be devised and standardised. Was not it a fact that the filters used were simply to assist the observer in comparing the brightness of two surfaces of different hue, and that a rough match was all that was necessary to get reasonable ease of brightness matching.

He could not follow Mr. Buckley's statement that the high pressure mercury lamp contained a blue line of low luminosity but high colour value. Was it not a fact that all lines in the spectrum were of equal purity?

Mr. Oakley had suggested that the photometry of lamps by brightness measurements, and by the energy distribution were two fundamentally different things. Yet in the introduction to Mr. Buckley's paper one found that method number (3) was simply one of three different techniques all directed towards the ultimate criterion of the relative brightnesses of two sur-

faces lit by the comparison source and that under test.

He felt it was time that an authoritative statement on simple first principles was made. Suggestions were sometimes made which challenged these principles, and were apt to prove confusing to practical illuminating engineers. It had, for example, been claimed that visual acuity was higher under monochromatic light than under ordinary light courses. This might or might not be true, but in any case visual acuity should not be confused with illumination, which was defined and measured in terms of the brightness of. a surface of defined properties. Engineers were apt to be confused by the emphasis placed by laboratory workers on the difficulties of heterochromatic photometry, and to infer that there was something unique about white light rendering necessary new units of measurement when so-called coloured light sources were tested. Actually the fundamental quantity to be measured was still brightness, and the laboratory workers' efforts were directed simply to enable comparisons of brightness to be made more easily and consistently.

In the vast majority of practical cases of street lighting vision was by the silhouette method, and the object was seen by the observer as a dark object against a light background. Ability to see the object was thus governed by the brightness contrast between object and background (the street surface). Owing to the generally drab clothing worn in this country, and the low level of illumination prevailing, colour discrimination played an insignificant part. So far as street lighting was concerned, therefore, the definition of illumination and lumens held good and satisfied all practical requirements. Confirmation of these facts would do much to clear up fundamental ideas and to combat the growing tendency to suggest new yardsticks to suit special circumstances.

Mr. A. W. Beuttell remarked that Mr. Buckley's paper had been directed mainly to the accuracy of heterochromatic photometry, and from the point of view of the photometric bench. He did not think it fair to draw him away from his beat. He would, however, like to raise one general question. Mr. Buckley had dealt with the photometry of luminous discharge tubes from the point of view of their candle power. These lamps were being very largely used for street lighting and flood lighting for the illumination of objects, but it must be born in mind that a very large number of these tubes were in use for spectacular and advertising purposes. He was not quite sure whether, under such circumstances, it was the candle power of the source that really mattered —whether, for instance, brightness or the actual candle power per square inch was not more material. He did not know of any data or discussions which would throw light on this particular subject.

Dr. J. W. T. Walsh (*Communicated*): There is one part of Mr. Buckley's paper to which the attention of illuminating engineers should, I think, be specially directed. He points out that at low levels of illumination the visibility curve of an observer may change with the brightness level, even with a small field size; it certainly does so with a large field size, as we all know. This effect is such that we are at once brought up against the meaning of the term " equality " in the case of illuminations by lights of different colours. Let us consider a concrete example. Suppose that we have two streets, one lighted by lamps giving red light, and the other by lamps giving blue light. Further, let both kinds of lamps have the same candle-power distribution, and let them be similarly mounted. If the maximum illumination be, say, 0.5 foot-candle in each case, and the minimum illumination in the blue street 0.02 foot-candle, we should naturally expect the minimum illumination in the red street to be 0.02 foot-candle too. It is possible that, if measured with a photometer having a small field. the difference between the observed figure and 0.02 foot-candle would be small. On the other hand, to the ordinary " man-in-the-street," who looks at things with the naked eye, and therefore, presumably, employs a large field size, the minimum illumination in the " red " street would be obviously much less than that in the " blue " street, and if anyone told him that they were the same when measured with a photometer, he would be more than likely to remark, " So much the worse for the photometer! "

It seems to me that this is a situation which illuminating engineers must face frankly and deal with, as far as possible, both by positive and negative action. By " negative action " I mean that no figures of illumination should be given for coloured lights when the illumination is below about 0.02 foot-candle, unless the conditions under which the measurements are made have been carefully specified. By " positive action " I mean that agreement should be reached as soon as possible on standard conditions of measurement. It seems reasonable to define equal illuminations at *all* levels as equal fractions of illuminations which are equal at a level where the conditions of measurement do not appreciably affect the results obtained. How the values at low levels are to be obtained is at present only imperfectly known, but, no doubt, further research will indicate a suitable procedure. Then, as a further step, the relation between the colour of the light and the " apparent " brightness of an extended field having any given " real " brightness must be investigated, so that the readings of the photometer may be interpreted in a manner which will not offend the common-sense judgment of the " man-in-the-street."

Mr. J. S. Dow (*Communicated*): The subject of Mr. Buckley's excellent paper is an old favourite of mine—though in the days when I studied heterochromatic photometry we had no such formidable difficulties as those involved in the comparison of electric discharge lamps to consider.

Mr. Buckley's masterly survey gives good ground for inferring that even these difficulties may be overcome in the photometry laboratory. But although I agree in the main with Mr. Damant's contention that one should not confuse photometry, which is essentially based on brightness, with tests of acuteness of vision (or other special qualities said to be influenced by the new lamps)—one should not blind oneself to fact that even appraisal of brightness is not all plain sailing.

If one were concerned simply with the problem of devising methods that would give consistent results in the laboratory, one could trust Mr. Buckley and his colleagues to find a way out. But the problem goes deeper than this. It involves the further consideration: " How far do these photometric tests, even if consistent, correspond with the comparative impressions of brightness produced in practice?" People are apt to think of the Purkinje effect (which in its full significance includes not merely results of diminutions in intensity, but also of variation in the area of the retina covered by the object examined) as purely an effect found in the laboratory. Actually it is one that influences impressions of brightness as seen by the eye whenever highly-coloured objects—or white objects illuminated by highly-coloured light—are in question.

The familiar phenomenon associated with the appearance of red geraniums in the dusk illustrates this. In bright sunshine the flowers are brighter than the leaves. In the twilight they appear much darker—becoming almost jet black when the eyes are brought near to them, whilst the foliage assumes a livid grey appearance. One can readily imagine, therefore, that a comparision of two sources, one pure red and one pure green, based on the observation of small surfaces relatively brightly illuminated in the photometer room might suggest something quite different from what would, in fact, be seen when large outdoor areas were illuminated to a feeble degree by the two sources. One

would expect the practical test to prove more favourable to the green end of the spectrum so far as impression of brightness is concerned—though in other respects the accentuation of the green end of the spectrum might be less expedient.

Dr. S. ENGLISH (*Communicated*): I am very disappointed that I cannot be present at the meeting of the I.E.S. to-night to hear Mr. Buckley present his paper on "Heterochromatic Photometry." I have, however, read through a proof of this paper, and would like to offer a few comments on it.

In the first place, I would like to express my appreciation of the way in which Mr. Buckley has collected so much information on this most difficult subject, and to set it out so that members of the Society, who are interested in this subject, but who, like myself, have failed to keep themselves as well informed as they should be, may bring themselves up to date.

Secondly, I would like to register my agreement with Mr. Buckley when he speaks of the difficulties encountered in trying to determine the equality of brightness of two juxtaposed areas of different colours. Even when the colour differences are not very marked, I am unable to satisfy myself as to the correctness of a brightness match. I have met this difficulty in the testing of refractors for gas street lighting, using an electric vacuum lamp for comparison purposes. So dissatisfied have I been with the lack of precision in the balancing of the fields in the Lummer Brodhun head, that I have more than once left the testing of experimental and first sample units to others, who were able to obtain a satisfactory match.

In the measurement of the light given by the so-called artificial daylight and semi-correcting units, I have employed the method involving the use of filters transmitting definite portions of the spectrum. Such measurements gave an idea of the spectrum distribution curve of the units, but the juggling (if I may use the word) with such figures and converting them into candle powers, even though the colour of the light is vastly different from that of a candle or of a standard lamp, seems to be little more than a complicated mathematical exercise. For instance, it is difficult to visualise the meaning of saying that the candle power of a Neon lamp is so much, when the spectral distribution of the light from the Neon lamp is so very different from that of any ordinary lamp. The two things do not seem to be comparable at all.

I am rather surprised to find that Mr. Buckley has not mentioned the possibility of using photo-electric cells with suitable filters as a means of measuring the output of coloured light sources. I know full well that when carelessly used, photo-electric cells are liable to give very misleading indications, but during the last four years I have used several cells of various types, and from some I have had very satisfactory service. In view of the rapid advances that have been made in the manufacture of such cells, I should have thought that it would have been possible to have obtained a cell which, when fitted with a suitable filter, would have had a spectral sensitivity practically the same as that of the eye of the mythical standard observer. Such a cell would, within limits sufficiently close for many practical purposes, give a measure of the effect of a light—irrespective of its colour—on the normal eye. At the present time, the precision of such an instrument would probably not be so high as that attained in the measurements recorded by Mr. Buckley, but the simplicity of the apparatus and the ease of measurement would appeal to many.

Mr. H. BUCKLEY, in reply to Mr. Winch, explained that with the equality of brightness method the contrast field was used for the large field, and a simply divided field for the small field. He regarded the visibility data as defining the only practical photometric scale we possessed; they were correct by definition. It was, in his opinion, the duty of photometrists to obtain results in accordance with that scale. If the result obtained by any other method agreed with that obtained by a method which depended on the visibility data so much the better. If not, then it was in principle wrong. As a matter of practical convenience, in view of the difficulty of making accurate spectrophotometric measurements, he could agree with Mr. Winch, and would give another method weight if the difference between the results obtained by the two methods was not very serious, e.g., not much more than the estimated possible error of the spectrophotometric method. The question of consistency, in his opinion, did not arise. If the more consistent method gave results different from the "correct" method, it was still wrong. The solution was to take more measurements by the "correct" method. As regards the low values obtained by the flicker photometer for the highly coloured blue and blue green glasses, he thought the low values were real. It was, however, a tribute to the work of Ives, Gibson, and Tyndall, and others that the agreement of the flicker and calculation methods was so surprisingly good. He believed that he shared Mr. Winch's opinion that the flicker method was the most convenient method of measuring highly coloured lights, and that the difference between flicker photometer results and the "correct" results did not really matter very much in practice.

Replying to Prof. MacGregor-Morris, he stated that Mr. Preston had answered his question about photo-electric cells. In using photo-electric cells all workers attempted by means of correcting filters to make the cell behave like the eye defined by the visibility data. In visual methods there was as yet no agreement that the method should be such as to give results in accordance with the visibility data. Prof. MacGregor-Morris's suggestion to use a comparison lamp of the same type would eliminate heterochromatic photometry in the street, but the comparison lamp would have to be calibrated in the laboratory by some method of heterochromatic photometry. He agreed that with two lamps of the same type the precision would be high with a large field. The precision with a small field was always much less than with a large field.

Replying to Mr. Preston, he did not think that the low results obtained for blue and blue green filters by means of the flicker photometer were due to colouration of the magnesium oxide screen. Experiments with a newly whitened screen confirmed results obtained with a screen the coating of which was over twelve months old. The suggestion that physical measurements throughout the spectrum be made and weighted in accordance with the visibility date could not be adopted at the moment as the necessary technique had not yet been developed. It was probable that developments in radiometry would make the method possible in the next few years.

In reply to Dr. Rayner he stated that one could never be certain that the mean of the results of a limited number of observers really represented the result which would be obtained by the average eye with ten observers possessing Y/B ratios on both sides of unity; one would expect the results to give a reasonable approximation to the correct result under the given conditions.

Answering Mr. Oakley, he stated that the discharge tubes were all operated on direct current. The filters used to produce colour matches were not such that one could specify them to the glass maker. They had to be selected from a large number available and tested in various thicknesses. The probable error of the mean of ten observations with full colour difference was a misleading quantity. The probable error might be quite small on one occasion and on another occasion equally small, but the means of the two sets would differ by several times the probable error. As regards measurements in integrating spheres it was to be expected that errors due to non selectivity of the sphere paint would be greater than those met in the photometry of tungsten lamps. The reflection factor of the sphere paint might differ slightly for the light

of the discharge tube and for the filtered light which colour-matched it. If the reflection factors differed by 1 per cent. for a sphere paint of reflection factor of 80 per cent. one would expect errors of the order of 5 per cent.

In reply to Mr. Oakley's question on the effect of adding red light to a mercury lamp, one could not conclude that the difference between the small and large field values would be greater. With the filter described in the paper it probably would be. But with another filter which gave a perfect energy match the difference in the large and small field results would be zero and with another filter it might be reversed in direction.

Replying to Mr. Davis he agreed that standardisation of methods was desirable. In his own opinion the basis of standardisation was the agreed visibility curve, and as he had stated in reply to Mr. Winch, it was the business of workers in photometry to obtain results in accordance with the photometric scale defined by the visibility data. As regards the methods by which the usefulness of discharge lamps could be assessed for " seeing " purposes, this was not a photometric problem. Photometry was based on the comparison of brightness, and other methods would have to be used if the utility of light sources apart from their ability to produce brightness was investigated.

In reply to Mr. Waldram it certainly was a fact which had surprised him at first that in the case of the mercury vapour lamps the results obtained by the equality of brightness methods with no colour difference with large and small fields when plotted against Y/B ratios gave lines having no definite slope. He drew the conclusion from this that the Y/B method breaks down in these cases.

The results obtained with the full colour difference did, however, give lines having a more or less definite slope, as was expected. He agreed with Mr. Waldram that the lamp was a very important part of a portable photometer, and that if highly selective filters were used it should operate at a known colour temperature. Fortunately, a change of 50 per cent. in colour temperature did not affect the transmission of any except the extreme red filters by very much.

He agreed with Mr. Damant that an approximate colour match was all that was required in the measurement of discharge tubes. It was, in general, impossible to get a filter which would give an energy and colour match simultaneously so that all observers would get the same result. All that was necessary was a colour match sufficiently good for each observer to feel no difficulty in brightness matching, so that the variations in his day-to-day settings were small compared with the differences between observers. In reply to Mr. Damant's query about the luminosity and colour value of blue light, he stated that the addition of an amount of blue light to a source could be small in its effect on the candle-power, but yet could produce a considerable colour change.

In reply to Mr. Beuttel, he agreed that the question of the visibility of signs using discharge tubes was an important, but quite separate, problem from that of the determination of candle power. It was probable that brightness rather than candle power was one of the factors influencing the visibility of such tubes used for advertisement purposes.

Both Mr. Dow and Dr. Walsh have raised the question as to how far the photometric tests correspond with the comparative impressions of brightness produced in practice. Unfortunately, we have to admit that whilst for the hypothetical average observer the brightnesses of certain geranium leaves and flowers may be the same, for all real persons they appear different. This is a difficulty which is not to be overcome by means of new definitions of photometric quantities. It is inherent in the fact that no photometric scale can exist for an instrument which exhibits a Purkinje effect. No instrument gives results which have any quantitative meaning except within that range of brightnesses over which its visibility curve is constant. For the hypothetical observer defined by visibility data, the range is infinite, so that he can be made the basis of the photometric scale. Real observers each have their own photometric scale over that range of brightnesses in which there is no Purkinje effect. This range for the small field size goes down to very low intensities. For large field sizes the range is smaller, and the brightnesses encountered in street lighting are in the region where there is no photometric scale for coloured lights. Comparisons of brightnesses can, of course, be made, but the numerical values deduced from them have no meaning unless the field size, field brightness, and observer are specified. The adoption of a standard method would eliminate the necessity of stating these conditions. It would at the same time emphasise the fact that heterochromatic photometry can only be carried out under certain very definitely defined conditions.

In reply to Dr. English, it should be stated that once the visual values are determined it is possible to apply correction factors to any photo-electric cell, even if its sensitivity curve is different from that of the eye. The correction factor would, of course, be different for each type of lamp. To make a filter which made the cell equivalent to the average eye is, however, more difficult. My colleagues, Mr. Preston and Mr. MacDermott, are working on this problem.

In conclusion, I would like to acknowledge the complimentary remarks which have been made with regard to the paper and the cordial way in which it was received by the members present. At the same time, I wish to point out that the paper represents the joint work of a team, and that very much credit is due to my principal collaborators, Messrs. Barnett, Brookes, and Hale.

Annual General Meeting

The **Annual General Meeting** of the Illuminating Engineering Society is to take place in the Lecture Theatre of the Institution of Mechanical Engineers (Storey's Gate, Westminster, S.W.1) on **Tuesday, May 8th (6.30 p.m.).**

After the presentation of the Annual Report of the Council and the Accounts for the past year and the transaction of the usual formal business, an Address on **Recent Progress in Illuminating Engineering in the United States** will be delivered by MR. SAMUEL G. HIBBEN (Director of Lighting for the Westinghouse Company, New York City), who has come over specially for the purpose.

Mr. Samuel G. Hibben.

Mr. Hibben has had a wide experience of lighting problems. He has had much to do with developments in diffusing glassware and indirect lighting, with underwater lighting, searchlight design, and the lighting for pageants and exhibitions. Recently he has been studying the development of electric discharge lamps and their numerous applications.

Members are asked to make a special effort to be present on this occasion to welcome Mr. Hibben and to bring with them, as visitors, friends who would be interested to hear his address.

National Illumination Committee of Great Britain

(Affiliated to the International Commission on Illumination)

Report for the Year 1933

(Presented at the Special Annual Meeting of the Committee on Wednesday, March 7th, 1934)

As a result of the postponement of the next plenary meeting of the International Commission on Illumination from 1934 to 1935, the Committee has not been quite as active as usual. The work of the sub-committee has, however, progressed favourably, and with the additional year which has become available before the next plenary meeting, considerable progress should be recorded.

The extension in the work undertaken by the I.C.I., and in consequence by the various national committees, has made the Committee more and more that of a supervising body, and nearly all the work is carried out by the various sub-committees. Of these there are now twenty-two, three of which have been set up during the past year. These deal with Ultra-Violet Light, Shadows, and Mine Lighting. The National Committee has accepted the secretariat responsibility on behalf of the International Commission for the organisation of work in connection with the study of Mine Lighting, and a strong sub-committee has been appointed. Progress in connection with the other sub-committees is reported below.

Lighting Education.

As reported in last year's report, the sub-committee called the attention of the various organisations interested in Illumination to the increased need of specialist education for the illuminating engineer. As a result a very successful course of ten lectures on various aspects of illuminating engineering were given in the Spring of 1933, at the Regent-street Polytechnic. The lectures were well attended, and it is expected that they will be published shortly. During the present session a post-graduate course of illuminating engineering is being given at the City and Guilds (Engineering) College.

Diffusing Glassware.

The revision of the specificaton for Translucent Glassware Fitting, No. 324, was completed during the year, and sent to the interested organisations for criticism. The thermal endurance test has been considered to be too severe, and further investigations have now been commenced with a view to modifying the thermal endurance requirements. A specification for a yellow diffusing bowl for use on Traffic signs and signals has also been prepared.

Coloured Glasses for Signal Purposes.

A specification for coloured lenses for railway signals has been prepared and will shortly be circulated to the interested organisations for comment. A specification for coloured Bull's-eye Lenses has also been prepared.

Aviation Lighting.

A specification of Aerodrome and Airway Lighting has been completed and sent to the interested organisations for comment.

Artificial Daylight Units.

Good progress has been made in the preparation of a specification for a daylight colour (or partially corrected) unit for general purposes. Work on a unit for colour matching purposes will be considered shortly.

Street Lighting.

An extensive revision of the existing specification has been actively considered by the sub-committee during the past year, but much work still remains to be done before it can be completed.

Light Distributions.

The sub-committee has been in communication with the German Committee with a view to making the British and German proposals for a classification based on flux distributions more nearly alike. The German proposals have been modified by the inclusion of a class to correspond with the British " general " class, but the limits separating the various classes are still different.

Progress has also been made by the sub-committees on Photometric Accuracy, Heterochromatic Photometry, Photometry of Luminous Discharge Tubes, Automobile Headlights and Glare.

Several changes have taken place in the membership of the National Committee during the past year. Mr. Hadyn T. Harrison, who was one of the original members of the committee, has unfortunately found it necessary to retire on grounds of ill-health. His place has been taken by Mr. R. W. Gregory as representative of the Institution of Electrical Engineers. Colonel H. V. Prynne, representing the General Post Office, and Dr. A. H. Levy, representing the Illuminating Engineering Society, have also resigned from the committee. Miss Haslett has been nominated to the committee as a representative of the Illuminating Engineering Society, and Dr. H. H. Bashford as the representative of the General Post Office.

The National Committee again wishes to thank all the organisations who have co-operated in its work and their representatives who have placed so much of their time and experience at the service of the Committee.

K. Edgcumbe (*Chairman*).
H. Buckley (*Hon. Secretary*).

Progress in Illumination

Successful Meeting Organised by the North-Western Section of the Illuminating Engineering Society in Manchester on March 15th

AS already reported, the section of the Illuminating Engineering Society in the North-Western Area held a very successful meeting in the College of Technology, Manchester, on Thursday, March 15.

The President of the Society—Mr. C. W. Sully—delivered a somewhat modified version of his address on "Artificial Lighting—a Vista of the Future," to an audience which was too large for the hall that had been engaged for the meeting. Numerous exhibits illustrating recent advances in illuminating engineering were on view.

Mr. Sully's address, which was based on that previously delivered in Birmingham,* served to illustrate the variety of trade interested in lighting, the many problems now claiming attention, and the useful part played by the Society in this connection.

In what follows we give a list of the various exhibits. The representative series of exhibits illustrating gas lighting, which had been brought together by the Chief Engineer of the Manchester Corporation Gas Department, Mr. A. L. Holton, was very ably demonstrated and explained by a member of his staff, Mr. Mainwaring. The various electrical exhibits were dealt with individually by representatives of the firms concerned, who deserved credit for the manner in which they kept within the allotted time. thus enabling a programme of distinctly generous proportions to be carried through.

GAS EXHIBITS.

1. *J. Keith and Blackman, Co., Ltd.*
   (a) High Pressure Indoor Decorative Lamp, illustrating a considerable improvement in the appearance; also the silent burning of the lamp.
   (b) New type of High Pressure Lamp embodying improved pre-heating of the gas and air, using smaller mantles than is customary.
   (c) Low Pressure Decorative Lamp. In this type the regulators are entirely enclosed and the lamp gives a pleasing appearance.
2. *Chance Brothers and Co., Ltd.*
   A new type of decorative globe for indoor lighting, square in shape giving a modern appearance.
3. *Foster and Pullen, Ltd.*
   Suspension lamp, fitted with Holophane refractor between the globe and the cluster burner. In that position the refractor serves to deflect the light rays and also prevents the cold air stream from impinging upon the mantles, thus maintaining a higher flame temperature.
4. *W. Parkinson and Co., Ltd.*
   (a) Curved Top Reflector Lamp, with "Mor-lite" Reflector below the mantles.
   (b) Floodlight of the alignment type.
   (c) The Parkinson Jet balance for calibrating a number of jets against a master jet.
5. *W. Sugg and Co., Ltd.*
   (a) Upright Rochester Suspension Lamp, fitted with multi-ray reflectors.
   (b) The Tower Bridge Grosvenor 3-pane lamp, incorporating symmetry in design to suit the general surroundings of its position. The lamp derives its name from the fact that the type is erected on the Tower Bridge, London.
   (c) Floodlights of the projector and prism-surfaced reflector type.
   (d) Rochester lamp with Holophane Dish refractor.
6. *C. H. Kempton and Co., Ltd.*
   Two-way "Kempar" Lamp, which introduces a departure in design and construction. It has stainless steel "Parabolic" reflectors extending the full length of the lantern with 4 bijou burners in front of each reflector.
7. *The Horstmann Gear Co., Ltd.*
   (a) Time Gas Switch for automatically extinguishing a light after a pre-determined time ranging from one minute to two hours. It is particularly designed for extinguishing a stair light or similar unit.
   (b) The By-pass lighting switch.
   (c) The Catalytic Ignition Switch, which renders unnecessary a by-pass switch, except for a few minutes at lighting time.
8. The "Bloor" by-pass Nozzle was also on view, which has a consumption of approximately 1/10 cubic foot per hour.

ELECTRICAL EXHIBITS.

1. *Automatic Light Control, Ltd.* (Mr. Barber).
   (a) Selenium Bridge control unit for automatic lighting of streets, etc. The apparatus is so placed that full daylight impinges on the selenium bridge, and under this condition the contractor switch is "open" and the lighting circuit "off." When daylight falls below a definite value less light impinges on the bridge, resulting in a variation in its resistance, thus causing the contactor switch to "close" and bring the lighting into operation.
   (b) "Corrected" all enclosed lighting units to obtain a white light.
2. *Benjamin Electric Co., Ltd.* (Mr. H. Long).
   "Sooflux" fittings, the use of which it was claimed would prevent an increase in temperature in the wires near the lighting unit.
3. *Chance Brothers and Co., Ltd.* (Mr. Holmes).
   Various examples illustrating improvements effected in the manufacture of pressed glass for refracting the light and also coloured glass for neon tubes, etc.
4. *Everett, Edgecumbe and Co., Ltd.* (Mr. Hopkins).
   Portable "lumen-cube" photometer, which enables the output of a lamp in lumens (or candle-power) to be read direct on a scale, in addition to the power consumption in watts.
5. *British Thomson Houston Co., Ltd.* (Mr. Ruff).
   "Sun" and gaseous discharge lamps (horizontal type).
6. *Edison Swan Electric Co.*
   Turret floodlight—a floodlight of the projector type.

* Illum. Eng., April, 1934, pp. 125-128.

7. *E.L.M.A. Lighting Service Bureau* (Mr. G. H. Wilson and Mr. Galley).
   (a) Polar curve machine—an ingenious arrangement, operated photo-electrically, whereby a spot appears on a rotating surface. By following the spot a polar curve is obtained.
   (b) A model building, on which effects of correct and incorrect floodlighting could be shown, was exhibited. This illustrated the necessity for co-operation between the Architect and Illuminating Engineer.
8. *General Electric Co., Ltd.* (Mr. Jepson).
   (a) Electric Gaseous discharge fittings, applied for coloured floodlighting were illustrated at the entrance to the theatre. Colour-connected electric discharge lamps and portable photometers were also shown.
9. *Hailwood and Ackroyd, Ltd.* (Mr. Winn).
   Various examples of modern illuminating British glassware were displayed.
10. *Holophane, Ltd.* (Mr. Schofield).
   The Duo-Dome Refractor. Smooth both on exterior and interior 2-way refractor.
11. *Philips Lamps, Ltd.* (Mr. Gostt).
   Sodium Electric Discharge Lamps.
12. *Siemens Electric Lamps and Supplies, Ltd.* (Mr. Aldington).
   A comparison between an uncorrected and a corrected electric discharge lamp, illustrating the difference in colours under the two lamps.
13. *Revo Electric Co., Ltd.*
   Fittings for gas discharge lamp.
14. *Stafford and Leslie* (Mr. Leslie).
   Portable Photo-Electric Photometer.
15. *Simplex Electric Co., Ltd.* (Mr. Allpress).
   Fitting for electric discharge lamps and flame-proof fittings, chiefly designed for use in mines.

An interesting explanation was also given by Mr. Davey of the illustration of Isocandle diagrams by means of coloured plastic models.

The smallest exhibit—viz., the "Bloor" by-pass—caused much amusement by the many unsuccessful attempts that were made to extinguish such a small flame. Great interest was also shown in the various electric gaseous discharge lamps, especially the new colour-corrected type. A striking example of colour variation was given by the display of a roll of cloth under various sources of illumination. Under the ordinary gaseous discharge lamp the colour was naturally much distorted; under the "corrected" lamp it was a pale pink, while under an electric incandescent lamp or the various incandescent lamps the material appeared the correct deep red colour.

The new type of high-pressure gas lamp, with its clear white light, and the other examples of modern gas lighting, also attracted much interest, and likewise the lighting and extinguishing by-pass switches, and the catalytic ignition controllers for the control of gas lighting.

Most exhibitors noted a marked improvement in the gas exhibits, and were very generous in their congratulations. The explanation of the working of the intricate selenium bridge control for automatic control of electric units was also much appreciated.

The exhibits showed very clearly that illuminating engineering is by no means at a standstill, and that considerable progress had been made in many directions during the past year. This fact was well illustrated not only in the electrical sections, but in the surprising number of gas exhibits, which demonstrated that advances are also being made in this field, especially in connection with street lighting.

After votes of thanks had been recorded to the Chairman, Demonstrators, and the College of Technology for their valued assistance in contributing to the success of the meeting, the President invited the audience to inspect the various exhibits.

The keynote of the meeting was that of progress achieved by the various sections of the lighting industry. The local section of the Illuminating Engineering Society in the North-West Area is to be congratulated on organising such an exhibition. The appeal for increased membership of the Society will, we hope, meet with deserved support.

The Photometry of Gaseous Discharge Lamps

Mr. D. G. Sandeman has drawn our attention to an omission in the printed version of his communication on the above subject which appeared in our last issue (ILLUMINATING ENGINEER, April, 1934, p. 140). The captions under the first two illustrations were inadvertently omitted. It should be explained, therefore, that Figure 1 represented, in a vertical plane, the polar curve of light distribution of the bare lamp, and the altered distribution as modified by the use of a prismatic bowl. Fig. 2 represented light distribution approximately 15° below the horizontal; curve A relating to a 500-watt incandescent lamp in a prismatic bowl, and curve B to a mercury discharge lamp, also in a prismatic fitting.

In regard to the final paragraph of his letter, Mr. Sandeman explains that whilst the intensities of illumination were substantially the same in the two cases, the stretch of roadway illuminated by the gaseous discharge lamp appeared to be much the most efficiently lit. He also draws attention to what is evidently an important point—the colour of the road surface—which may have a material effect on comparisons of gaseous discharge lamps yielding light of different colours.

J. Wyatt Ife

Presentation on Retirement

We learn that Mr. J. Wyatt Ife, who for a period of thirty-eight years acted as Secretary of Holophane, Ltd., and who recently retired. has been the recipient of an illuminated address and a cheque from the directors and staff of the company, as a mark of recognition of his long period of useful service.

Mr. Ife's connection with the company was continuous and dated from its inception. Readers will recall that Mr. Ife also acted as hon. treasurer of the Illuminating Engineering Society ever since its commencement in 1909. On his retirement at the commencement of the present session, he was presented with a silver rose bowl by the Council and Members of the Society.

The many friends that Mr. Ife's kindly and genial personality has gained for him will be glad to learn that his connection with the Society—of which he is a life member—is still unsevered, and there will no doubt be opportunities of meeting him at its monthly meetings.

Literature on Lighting*

(Abstracts of recent articles on Illumination and Photometry in the Technical Press)

(*Continued from page 130, April, 1934*)

I.—RADIATION AND GENERAL PHYSICS.

92. The Spectrum of the Carbon Arc in the Red Region. H. Birkenbeil.

Zeits. f. Physik, 88 *pp.*, 1-13, 1934.

While the blue-violet region of the spectrum of the carbon arc has been much studied, the weaker lines in the red have been comparatively neglected. It is found that the red spectrum consists of (1) the cyanogen spectrum, (2) the first positive group of nitrogen bands, and (3) a carbon dioxide spectrum. The separation of these lines and bands is of considerable interest.

F. H. H.

II.—PHOTOMETRY.

93. The measurement of the intensity of light in absolute units using a black body of known low temperature. Miss J. G. Eymers and D. Vermeulen.

Revue d'Optique No. 10. *pp.* 392-395, *October*, 1933.

Describes the calibration of a spectral pyrometer and its use to determine the energy intensity emitted by a light-source. A black body of relatively low temperature (freezing point of gold) is used for calibration. The method is equally applicable to sources with continuous spectra and to line spectra.

L. J. C.

94. A simple and accurate method of standardizing photometric sub-standards of any colour temperature. L. S. Ornstein, Miss J. G. Eymers, and D. Vermeulen.

Revue d'Optique No. 10, *pp.* 390-391, *October*, 1933.

Existing primary standards of light possess a relatively low colour temperature, and in determining sub-standards of higher colour temperature by the usual methods the difficulties of heterochromatic photometry are encountered. The method of avoiding these difficulties described by the authors utilises a photometric sphere, in which are placed, in turn, (a) a lamp of known total lumens, (b) a lamp of known spectral energy distribution, and (c) the unknown sub-standard. In each case measurements are made of the relative intensity of the light from the sphere window at every wavelength of the spectrum. By adopting an agreed visibility curve of the eye the lumen output of the substandard can be readily determined.

L. J. C.

95. Unit of Light or Standardized method of measurement. L. S. Ornstein.

Revue d'Optique No. 10, *pp.* 764 *to* 769, *October*, 1933.

The authors criticise accepted ideas on the necessity for a standard of light. From the standpoint of physics a source is completely specified when the energy radiated by it per second per unit solid angle is known for each wave-length of the spectrum. A standardized method of measuring spectral energy distribution in absolute units is required.

The output of a source in lumens does not in general give an adequate idea of the efficacy of a source for any given purpose. Proposals are made for the specification of the light from sources with either continuous or line spectra in terms of the energy distribution, and the geometric distribution of the light. The luminous output of the sources can be derived from the proposed specification by the aid of an internationally agreed visibility curve of the human eye.

L. J. C.

96. Precision in Visual Photometry. Yves Le Grand.

Revue d'Optique No. 4, *pp.* 145-159, *April*, 1933.

The author studies the photometric concepts of differential sensitivity and precision and the influence on them of various factors. The arrangement of the photometric screens and the effects of separating lines between the screens, of variation of the apparent diameter of the photometric field, and of the method of observation are discussed.

L. J. C.

97. An Automatic Photoelectric Photometer. E. B. Moss.

Proc. Phys. Soc. 46, *pp.* 205-214, *March*, 1934.

A photoelectric photometer, operated from A.C. mains, is described. In its present form it is a convenient instrument for measuring the optical density of photometric filters. Light from a single lamp is separated into two beams, which by means of a rapidly moving shutter are made to pass alternately to a single photoelectric cell. It is arranged so that any inequality of the two beams leads to a sinusoidal photoelectric current.

The filter to be tested is inserted in one beam, and a neutral wedge filter in the other. The sinusoidal photo-current is amplified and then made to actuate a small motor which adjusts the position of the wedge until balance is obtained. A pointer attached to the wedge gives a direct reading of the transmission of the filter.

F. H. H.

98. The Illumination-Response Characteristics of Vacuum Photoelectric Cells of the Elster-Geitel Type. J. S. Preston and L. H. McDermott.

Proc. Phys. Soc. 46, *pp.* 256-276, *March*, 1934.

The present status of the vacuum photocell as regards proportionality of current to illumination is discussed. Data are given which show that while excellent cells are obtainable, no cell can be relied upon for precise work without being previously tested. A theory is given to account for the results. The illumination-current characteristic curve is found to depend upon the frequency of the light employed.

The bearing of the theory on the application of Talbot's law to non-linear photocells is discussed.

F. H. H.

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* Abstracts are classified under the following headings: I, Radiation and General Physics; II, Photometry; III, Sources of Light; IV, Lighting Equipment; V, Applications of Light; VI, Miscellaneous. The following, whose initials appear under the items for which they were responsible, have already assisted in the compilation of abstracts: Miss E. S. Barclay-Smith, Mr. W. Barnett, Mr. S. S. Beggs, Mr. F. J. C. Brookes, Mr. H. Buckley, Mr. L. J. Collier, Mr. H. M. Cotterill, Mr. J. S. Dow, Mr. J. Eck, Dr. S. English, Dr. T. H. Harrison, Mr. C. A. Morton, Mr. G. S. Robinson, Mr. W. R. Stevens, Mr. J. M. Waldram, Mr. W. C. M. Whittle, and Mr. G. H. Wilson. Abstracts cover the month preceding the date of publication. When desired by readers we will gladly endeavour to obtain copies of journals containing any articles abstracted and will supply them at cost.—ED.

III.—SOURCES OF LIGHT.

99. The Characteristics of the Sodium Lamp as Influenced by Vapour Pressure. G. R. Fonda and A. H. Young.

Journ. Opt. Soc. Am. 24, *pp.* 31-34, *February*, 1934.

Commercial sodium-vapour lamps contain sodium and an inert gas, usually neon. Sodium is a metal having a melting-point of 97° C., and a correspondingly low vapour pressure of about a millionth of atmospheric pressure at a temperature of 200° C. The neon, at a pressure of just over 1-1000th of an atmosphere, is introduced for the purpose of starting the discharge and of stabilising the discharge when, after about five or ten minutes, the light output has arrived near to its maximum. It has been found that the greatest luminous output from this neon-sodium discharge is obtained when the temperature inside the lamp is 200° C. The conservation of heat required to maintain approximately this temperature is effected by placing the lamps inside clear double-walled vacuum flasks. Results are given for an experimental lamp run at various current densities and temperatures, and some theoretical explanation is offered. F. H. H.

IV.—LIGHTING EQUIPMENT.

100. Uniform Light Distribution with Surface Radiating Soffitt Lighting.

Licht u. Lampe 23, *p.* 189, *March* 29, 1934.

Description of a fitting, now on the market, for tubular light sources. This fitting is claimed to give absolutely uniform illumination over large surfaces. E. S. B.-S.

101. Influence of Filament Form on Beam Characteristics with Shallow Paraboloids. G. Mili.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 191-202.

Test results are given for the beam characteristics from a 25-inch diam. 10-inch focus paraboloid when used with lamps having four filament forms. G. H. W.

102. Wiring of Neon Signs. Anon.

Elect. 112, *pp.* 421-422, *March* 30, 1934.

The particular requirements for the installation of high voltage cold cathode luminous discharge tubes are dealt with in detail. C. A. M.

103. Limiting Factors in Design of Motor Vehicle Headlamps. W. C. Brown and V. J. Roper.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 175-189, *March*, 1934.

After a statement of the desirable features of main and passing beams for headlamps, methods of obtaining such beams are discussed. The use of twin and triple-filament lamps is studied in relation to the design of the reflector. Focussing tolerances are dealt with, and there is a description of the multi-unit system employing a set of small headlamps. G. H. W.

104. Measurements on Rear Reflectors. W. Dziobek.

Zeits. J. Techn. Physik 12, *pp.* 557-559, December, 1933.

An account, with diagrams, of a method of measurement for rear reflectors. The problem is difficult because of the low value of reflected light and its red colour. W. R. S.

V.—APPLICATIONS OF LIGHT.

105. Illumination Distribution Measurements from Surface Sources in Side-walls. H. H. Highbie and W. A. Bychinsky.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 206-223, *March*, 1934.

Measurements were made by a photocell photometer of the illumination in a model room from diffusing wall panels. Data on uniformity of illumination and on the coefficient of utilisation are given for various arrangements of the wall panels. G. H. W.

106. Light and Architecture.

Am. Illum. Eng. Soc., Trans. 29, *pp.* 165-174, *March*, 1934.

Illustrated descriptions of eight modern lighting installations in the U.S.A. G. H. W.

107. Electric Lighting of Offices. Z. I. Folcker.

Licht u. Lampe 23, *p.* 187, *March* 29, 1934.

Description of a series of tests carried out in Sweden to determine the best type of lighting for offices. Hand and head shadows and glare from glazed paper were taken as the chief faults to be avoided. Semi-indirect lighting is found to be the most efficient. Direct lighting is the most economical where there is one light source for each working place. E. S. B.-S.

108. Lighting Impressions in Spain. F. W. Gerhard Schmidt.

Licht u. Lampe 23, *p.* 129, *March* 1, 1934.

The author gives a description of the lighting developments of the principal towns of Spain. Decorative coloured and concealed lighting has become popular for cinemas and cafés. Industrial lighting, especially in the textile trade, has been undergoing improvement. E. S. B.-S.

109. Satisfactory Lighting with Low Headroom. A. L. Powell.

El. World, 103, *p.* 396, *March* 17, 1934.

Describes the lighting of a foyer in the National Broadcasting Company's studios in New York, in which the headroom is restricted. Recessed ceiling fittings, and small wall fittings, are used. W. C. M. W.

110. V. Sodium Vapour Light for Street Lighting. C. G. Klein.

Licht u. Lampe 23, *p.* 168, *March* 18, 1934.

Outlines the advantages of sodium vapour lamps for this purpose. E. S. B.-S.

111. The Toll of the Roads and Public Lighting. W. J. Liberty, Roads and Road Construction.

Vol. 12, 135, *p.* 87, *March* 31, 1934.

Fatalities in relation to road lighting are discussed by the aid of an analysis of causation during hours of darkness. W. J. L.

112. Broadcasting Studios Present Interesting Lighting Problems. A. L. Powell.

El. World, 103, *p.* 367, *March* 10, 1934.

The lighting installation in the studios of the National Broadcasting Company, Radio City, New York, is described, and the problems encountered in the design of this type of installation are discussed. The standard of illumination aimed at in the studios is 20 foot-candles. W. C. M. W.

113. Mixed-Colour Lights Show Intensity Paradox. I. J. Suttinger.

El. World, 103, *p.* 334, *March* 3, 1934.

Gives results of twenty-one tests made to show the loss in visual effectiveness when red and blue lights are mixed to produce a white. W. C. M. W.

E.L.M.A. Twenty-ninth Illumination Design Course

The twenty-ninth Illumination Design Course is to be held at the E.L.M.A. Lighting Service Bureau (2, Savoy Hill, London) during the period May 7-11. An excellent series of lectures, covering such subjects as Illumination Design, Industrial and Domestic Lighting, Floodlighting, Architectural Lighting, Salesmanship, etc., has been arranged. The course will be illustrated by visit to installations of interest, and at its conclusion those taking part will be entertained to dinner at the Howard Hotel. No doubt the course will prove once more to be an exceedingly popular one. Therefore those who wish to take part and have not yet applied to the Bureau should lose no time in doing so.

The Examination of Polish

By J. M. WALDRAM, B.Sc., F.Inst.P.
(Research Laboratories of the General Electric Co. Ltd., Wembley.)

IN a recent article in THE ILLUMINATING ENGINEER (September, 1933, page 207) an account was given, taken from the Report of one of H.M. Inspectors of Factories, of the conditions of lighting in the factories of Sheffield; among others, in the silversmiths' shops. The trade of the silversmiths' has always been centred in that city, and many of their practices have remained unchanged —as have sometimes the very buildings which house them—for scores of years. In such factories change is slow, in lighting conditions as much as in everything else, and it is not surprising to learn that daylight is preferred to artificial light for the polishing and examination of the finished ware. Where artificial light is used, it consists generally of local gas-filled lamps in some kind of improvised shade. Mention was made in the Report of experiments in some cases with large sources of low brightness, such as large diffusing screens, as the small, very bright images formed in the polished surfaces were found to be harmful to the eyes after long periods of examination of silverware. Similar experiments were made in connection with the examination of stainless steel strip.

The surface of polished articles differs from many other types of surface which have to be lighted and examined for flaws, both in the type of flaw which has to be detected and in the fact that illumination of the surface, as such, has little to do with its appearance or the ease with which blemishes can be detected. The geometric form and brightness of the source and its position are the important factors.

In polished surfaces the flaws are of three main kinds: (i) departures from the proper contour of the article, such as dents or badly-formed curves (ii) scratches, and (iii) what may be called for want of a better term, poor finish; by which is implied buffing or spinning marks, or other such small irregularities similar, in fact, to those described under (i) but present on a much smaller scale. All three amount in fact to departures from the true contour of the surface which may be, in the third type, less than a thousandth of an inch in depth and a few hundredths wide. Such departures would be very difficult to measure by the ordinary methods of metrology, but they are comparatively easy to detect by the unaided eye under proper conditions, by means of their effect upon the images formed by regular reflection in the surface. Those who work with polished articles are accustomed, often unconsciously, to use this mode of examination; and it is, in fact, the appearance of the images which is really implied by the term "finish."

The better the finish, the less do small surface irregularities affect the images formed of external objects and the more brilliant and undistorted do they become. When dealing with very fine metal work, such as instrument and watchmaking, this is perhaps the only method of observation open to the craftsman, and with practice he achieves an astonishing delicacy of detection. It is said of one watchmaker, who was shown a finished ball-bearing, that he asked the maker, "Why don't you make it round?" and on being indignantly challenged, he marked three spots on the ball which he alleged were below the general level. The micrometer subsequently proved that they were, by one ten-thousandth of an inch. Such flaws could only have been detected by the slight distortion of some image formed by the ball. It is a refinement of the same principle which is used in the Foucault test used by the optician in testing the finish and "figure" of concave lens and mirror surfaces—the formation of which is perhaps the most delicate and precise work ever undertaken.

In the detection of such flaws, especially by operatives not necessarily so highly trained in the art, properly designed lighting devices can play a large part. Since the objects examined are almost always so held in the hand that the source is seen reflected in them, it becomes necessary to revise the general notions of the desirable forms of lighting device, for it is as important to consider what the object can see of the fitting or lamp as what the operator can see of the object. Instead of the illumination on the surface, the important criterion is rather the type of image which will be formed by reflection in it.

For the examination of polished ware, neither a small bright source such as a bare lamp, nor a large extended source, gives good results. Th image of the bare lamp is an intensely bright point, the remainder of the surface examined remaining dark. Flaws can be detected with such a source if the object is moved so that the bright point appears to move across the surface, but their detection is not easy. It is even less easy with a large extended source; the larger the source and the more even its brightness, the more do defects tend to disappear, until even a hammered pewter surface can be made to appear evenly bright and the hammer marks undetectable. Every facet reflects some part or other of the large source, and all parts are of the same brightness; it is only as the edge of such a source is seen reflected, that the flaws are seen; under that condition they appear surprisingly

Figure 1.

Figure 2.

clearly. If there is a dark surround to the large bright source, a point on the surface may, owing to a defect, reflect the dark surround instead of the bright source and appear as a dark speck. Similarly a defect at a neighbouring point may appear as a bright speck on a dark ground, and a mottled surface is shown up in sharp relief. All this takes place in the limited region near the edge of the image of a large source. Images of window bars and the like answer well for this purpose.

On this principle a simple device has been made which will render the defects very easily visible. All that is necessary is to provide a large source of fairly low brightness, crossed with dark strips or bands. If this course is reflected in the surface under test, and if the angular width of the strips as seen from the object is well chosen with regard to the type of defect encountered, it will be found that *small* scratches and bad finish at once appear. The eye must be focussed on the surface, and not on the image of the strips.

It should be noted that this use of a striped source is different from the use, to which it has been applied for a long time, for the detection of major irregularities such as dents. These can be seen with the strips at any reasonable spacing, and appear not in relief, as above described, but as kinks in the regular curvature of the images of the strips which have the appearance of contours running over the surface. The present application seems to be a novel one and no previous description has been found.* The distinction between the two can be seen in Figure 3, where the small surface blemishes are shown up as in relief, while the shape of the images of the strips is an indication of the contour of the iron.

Figure 1 shows a sample of an alloy, after partial weathering and re-buffing, reflecting the image of a large uniform source. Except in the centre, where the specimen was badly pitted, no defects are visible. Figure 2 shows the same specimen reflecting the same source covered with black strips ¼in. wide, separated by spaces of the same width. Figure 3 shows the side of a chromium-plated electric iron inspected with the same device. The iron appeared at a casual inspection to be well finished, and it is possible by this method to show up defects not otherwise easily seen.

What has been said with reference to reflecting objects applied similarly to transparent objects, such as blown glassware. Such ware, particularly better class objects, such as lamp bulbs, tumblers, chemical glassware, and the like, has to be examined for seed, cord, mould marks, etc., which are not easy to see in all conditions; the examiner instinctively holds them up to the glazing bars of the window in order to detect them. The present device makes such defects readily visible. Figure 4 shows two large lantern globes, the left-hand one of which has serious defects.

It will be realised that the defects shown on the photographs can be much more readily seen if the object is slowly moved about in the hand.

(Pat. applied for).

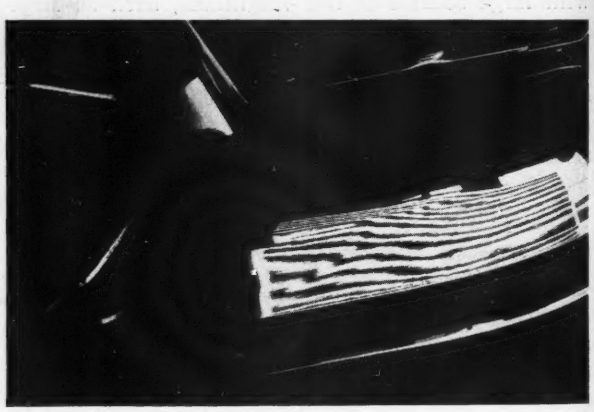


Figure 3.

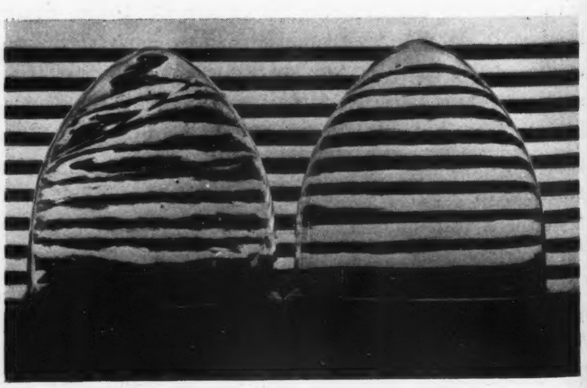
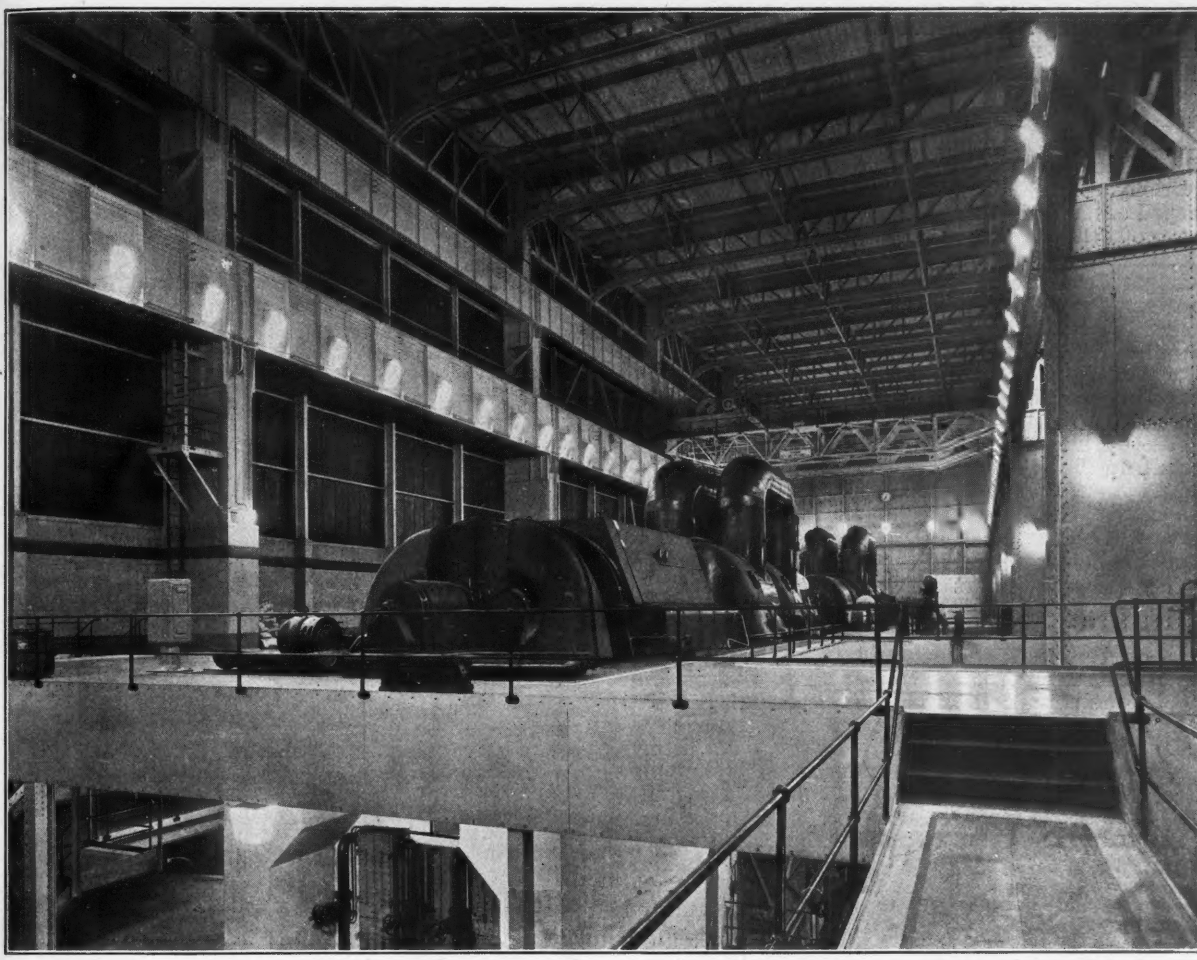


Figure 4.

* A somewhat similar device, using very narrow strips widely spaced, like the glazing bars of a window, is described by Ketch, Sturrock, and Staley, Trans. Ill. Eng. Soc. (Amer.), January, 1933, p. 57. This device would not give an indication of flaws at all positions on the surface unless the image were moved about.



A Night View (taken entirely by the artificial light of the installation) of the Turbine Hall in the new Barking Power Station. The hall is 290 ft. long, 78 ft. wide, and 67 ft. high. The floor area is 22,620 sq. ft., the cubic area of the interior 1,515,540 cubic ft. There are eighty 500-watt lighting fittings, with a consumption of 40 kw.; equivalent to 1.76 watts per sq. ft. of floor area, 0.88 watts per sq. ft. of combined floor and roof area, and 0.026 watts per cubic ft. of space. The fittings are seen mounted on the faces of crane girders and on the end walls, 27 ft. above floor level and 40 ft. below ceiling. Illumination 6 foot-candles.

The New Barking Power Station

Original System of Diffused Lighting

THE Barking Power Station, visited by members of the Illuminating Engineering Society on April 17, consists of two combined stations. The original (Station A) was opened by H.M. the King in 1925, and then contained plant of 100,000 kw. capacity. By 1931 the plant installed had been increased to 240,000 kw. The County of London Electric Supply Co., Ltd., then determined upon the erection of a supplementary station (Station B), in order to meet increasing demands, thus enlarging the total capacity to 390,000 kw.

The station is now the largest in this country, and the largest operating on one site in Europe.

The new section (B) cost approximately £2,000,000. The Turbine Hall (illustrated above) houses two 75,000 kw. turbo-alternators, the largest in service in Gt. Britain, which present a most imposing appearance. This is well illustrated in the photograph reproduced above, which also conveys a good impression of the size of the building in which they are housed.

The new boiler house contains eight units burning stoker-fired coal as contrasted with 26 units in the original Boiler House, some of which burn pulverised coal. The eight new boiler units in Station B have a normal evaporative capacity of 1,350,000 lb. of steam per hour, as compared with the 2,166,000 lb. per hour obtainable from the 26 boiler units in Station A. Special apparatus is provided to secure the elimination of dust from the flue gases.

The network of pipes on ceilings and walls throughout the new building is variously coloured—each colour denoting the work the pipe is doing. The grey, aluminium, and black of the machines and boilers make an impressive background.

Novel Lighting Arrangements.

Perhaps the most interesting feature, to illuminating engineers, of the new station is the novel method of lighting. This is well illustrated in Fig. 1; Figs. 2 and 3 are also informative in showing how the diffused light penetrates amidst complex and bulky machinery.

Briefly, the system involves the use of specially shaped units utilising panels of diffusing glass. There are no pendant fittings. Instead, the units are mounted direct on walls, girders, etc., skilful use being made of the inclination of the luminous facets to direct light upward and downward, as the case demands. No filaments are visible, and the low brightness of the surfaces serves to eliminate glare. The good diffusion of the light is aided by the good reflecting quality of the light grey tone in which most of the machinery is finished. The illumination on the working plane throughout this station ranges from 6 to 15 foot-candles. (Elsewhere even higher values have been provided, e.g., 45 foot-candles in the control room at Dunston Power Station, Newcastle-upon-Tyne, where the same system is used.)

The Turbine Room.

The full particulars in regard to the lighting of the Turbine Room are included under the illustration on the foregoing page (Fig. 1). The illumination on the working plane (6 ft.-c.) is furnished with a consumption of 1¾ watts per square foot, and the excellent impression made by the hall at night is by no means exaggerated in the photograph. The room appears to be filled with light. Each fitting serves a double purpose, illuminating all plant on the floor level and simultaneously illuminating the roof 40 ft. above the light sources. This double task is effected by the use of two distinct luminous facets, those visible in the picture, and subsidiary smaller inclined glass faces pointing upwards. Thus, the ceiling, instead of appearing like the roof of a gloomy cavern, with bright pendant lamps at intervals below it, appears uniformly illuminated and fully visible.

The Pump Bay.

The Pump Bay, parallel with and adjacent to the Turbine Room, is lighted by twenty-five fittings of the same type, placed on the back of the 175-ton crane girder, each carrying a 300-watt lamp. The wattage per square foot of floor is 1.17; or, if the roof is taken into consideration, 0.585. The wattage per cubic foot of space is 0.0018.

The absence of harsh shadows—which is a consequence of the extensive light-giving surfaces incorporated in the fittings—is well illustrated in Figs. 2 and 3. Lighting data are again present under these two illustrations.

It needs little imagination to realise the difficulty of lighting space occupied by a complicated mass of switchgear and pipelines, etc., but the problem seems to have been handled very successfully.

The Boiler House.

In the Boiler House, 230 ft. long, 130 ft. wide, and 100 ft. high, the problem was equally difficult, and again a special series of fittings was designed. The total lighting load is 60 kw., equivalent to 2 watts per square foot of floor area, but again the fact that 18 kw. are allotted to the lighting of the upper works and roof should be borne in mind. For the Firing Aisle (Fig. 3) six fittings each carrying four 500-watt lamps are attached to the main columns supporting the building. Fittings of an entirely different nature are fixed on the walls, serving to illuminate the upper regions, and other special types serve to illuminate the other passages and intricate parts.

We understand that the lighting fittings used throughout the new Barking Power Station were manufactured by the old established firm of Fredk. Thomas and Co., Ltd. (London), and were designed by their illuminating engineer, Mr. T. R. Dennett, in collaboration with Mr. L. C. Grant (then with Messrs. Merz and McLellan, but now Principal of Messrs. Sloan and Lloyd Barnes, Consulting Engineers, of Liverpool). We believe that, with the exception of the Turbine Hall and Control Room of Dunston Power Station, which as already mentioned is lighted by similar fittings and made by the same firm, the methods of lighting in this new Barking Station are unique. The County of London Electric Supply Co., Ltd., is certainly to be commended for their enterprise in this matter.

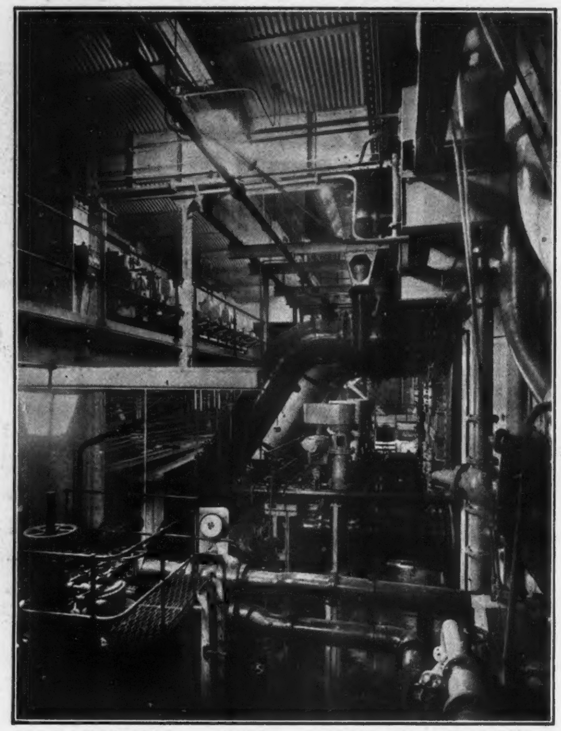


Fig. 2. Night Photograph (taken entirely by the artificial light of the installation) of Section of two floors underneath the Turbine Hall, containing switchgear, condenser plant, etc.

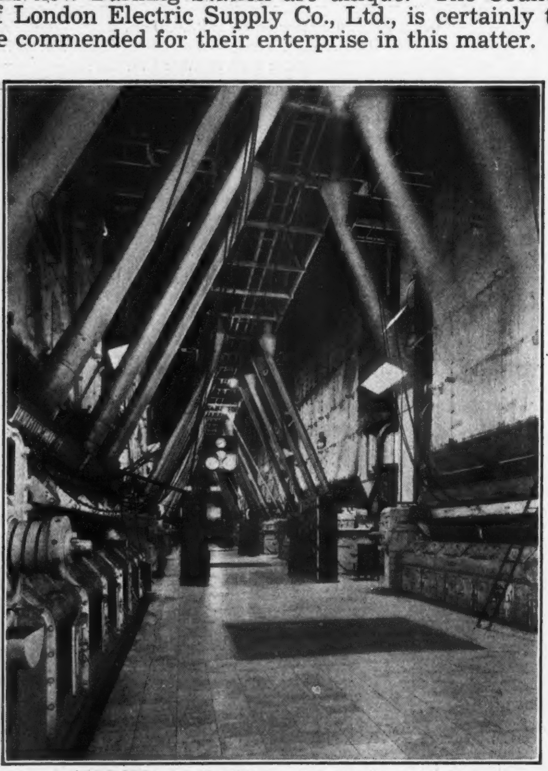


Fig. 3. Night Photograph (taken entirely by the artificial light of the installation) of Firing Aisle in Boiler House. The length is 290 ft., the width 30 ft., and the floor area 8,700 sq. ft. The main lighting is provided by six fittings, each provided with four 500-watt lamps, consuming 12 kilowatts, equivalent to 1.5 watts per sq. ft. The fittings are mounted on main columns, 25 ft. above floor level, one at the front of each side passage.

·WHERE TO BUY·

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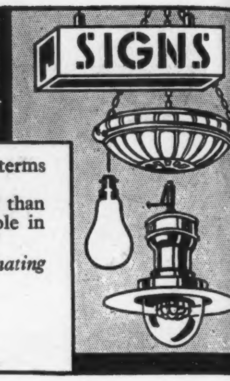

We invite applications for spaces in this new section of the journal. Particulars of terms for each space (approx. 1 inch deep and 3½ inches wide) are given below.

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London and North Eastern Rly.—Twelve months' supplies of Osram metal filament gas-filled and vacuum lamps, both pearl and clear types, including train-lighting lamps; also Robertson carbon filament lamps.

Twelve months' supplies of Osram lamps have also been ordered by *Aylesbury, Bootle,* and *Holborn Boroughs, Gloucestershire* and *Surrey County Councils, Poole Corporation,* and *Cleethorpes U.D.C.*

SIEMENS ELECTRIC LAMPS AND SUPPLIES, LTD.

London and North Eastern Rly.—Twelve months' supply of Siemens' electric lamps.

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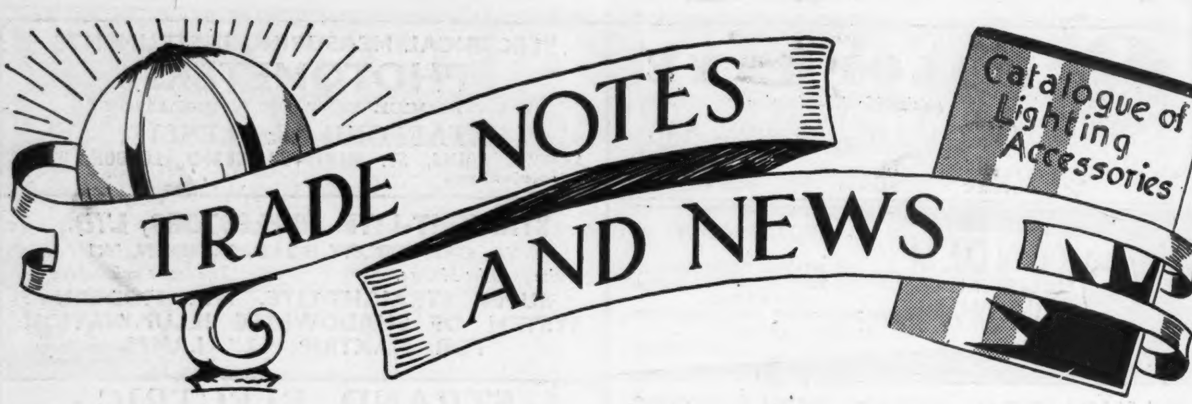
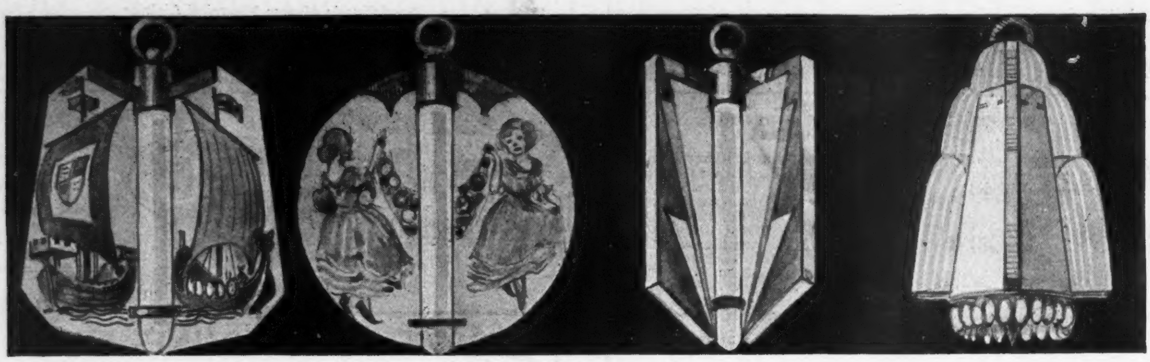
Belfast City Tramways—For the supply of Siemens' electric lamps during the ensuing twelve months.

Belfast Mental Hospital—For Siemens' electric lamps and other electrical materials during the ensuing 12 months.





Some of the pleasing designs on view in the showrooms of L. G. Hawkins and Co., Ltd. (Drury Lane, London). The design incorporating the ship in full sail is a particularly attractive one.

The New Decorative Lighting

This is the title of a very attractively prepared list issued by L. G. Hawkins and Co., Ltd., to whom we recently paid a visit. The new patent "Finray" fittings are here illustrated and very well displayed in the catalogue—yet they are naturally ever so much more pleasing when one sees the actual models! It will be noted that they are built up almost entirely of vanes of decorative glass assembled round a central tubular lamp of opal glass. A very pleasing feature is the mild sparkle of the coloured designs as the rays from this central lamp strike them obliquely. The decorative vanes all hang in vertical planes; hence they harbour little or no dust, and they are easily cleaned. We illustrate a few of these pleasing and varied designs. All are charming, but we have ourself a fancy for the one depicting a ship in full sail.

The "Gossama" fittings, which form the subject of a second distinct catalogue executed in colour, utilise rings, plates, and panels of coloured glass, which is well described as "silken." The light is completely concealed, so that the decorative effect of light coming through the coloured panels has full play.

In the course of our visit we were shown recent examples executed in diffusing glass and polished steel, of the characteristic indirect fittings with which this firm is associated. One observed, too, that whilst developing the new they do not despise the old, for there are plenty of pleasing fittings of conventional design also on view.

New Lighting at Lewisham

Lighting history was made at Lewisham on April 9, when the last section of a seven-mile installation of street lighting with electric discharge lamps was completed.

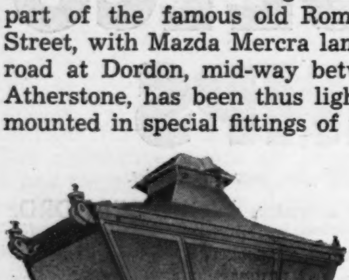
The striking picture below gives a good idea of the remarkable "spread" and diffusion of light by these

new units, which are mounted 25 ft. above the roadway on unbreakable columns, and project 5 ft. over the roadway. There are 224 units, 143 being on 200-volt and 81 on 230-volt A.C. supply.

A view of the offices of the Legal and General Assurance Co., Ltd., in Aldwych House, lighted on the G.V.D. system—a good example of the combination of laylights with pendant indirect units. The consumption is approximately 0.8 watts per sq. ft. Features are the soft shadow-effect and the good diffusion of light. We understand that over 21,000 sq. ft. of office space in the same building is lighted with these units.

A Famous Roman Highway Relighted

News reaches us of yet another interesting installation of electric discharge lamps—the lighting of a part of the famous old Roman highway, Watling Street, with Mazda Mercra lamps. A stretch of the road at Dordon, mid-way between Tamworth and Atherstone, has been thus lighted. The lamps are mounted in special fittings of the B.T.H. Diral type



The B.T.H. Diral Lantern as used on Watling Street with Mazda Mercra Lamps.

at a height of 25 ft., and the standards are 180 ft. apart. The lighting of this open stretch of roadway is very even and has been warmly praised.

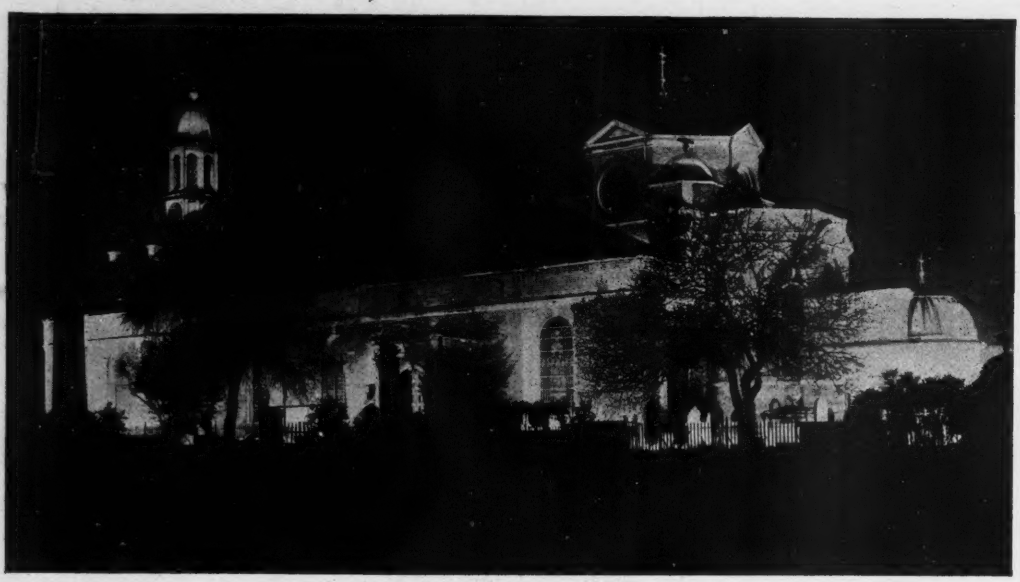
We notice that Mazda Mercra lamps have also been recently installed on a section of the Birmingham road between Dudley Station and Burntree Junction. In this case, however, lanterns of the Metrolux Directional type have been adopted.

Centrally Suspended Street Lighting

There are many who hold that, when it can be used, central suspension is incomparably the best method of street lighting. Certainly the method has advantages, such as a clear road free from lampposts. The London Electric Firm, of Croydon, issues a leaflet containing an impressive series of views of installations of this nature in the City of London, Glasgow, Eastbourne, Hove, and elsewhere. It is doubtless true that the public lighting of the City of London is amongst the best in the world, and that central suspension has been used there with conspicuous success. The leaflet also illustrates the auto-electric contact suspension gear, of which the London Electric Firm makes a speciality, and which is widely used in the towns and cities mentioned.

Sodium Electric Discharge Lamps

The "Philora" sodium electric discharge lamp, which is stated to yield 40 watts per lumen and is available in 100-watt size, is illustrated in a leaflet recently issued by Philips Lamps, Ltd. A picture of the familiar "Purley Way" installation appears on the cover, and various forms of fittings for street and industrial use are illustrated inside.



A CHURCH LANDMARK BY NIGHT

St. Anne's Church, Kew, was recently floodlighted by gas in connection with the Richmond Youth Campaign—a church missionary effort in which 100 campaigners are taking part. Thus lighted the church was a striking landmark.

Interchangeable Neon Window Signs

An ingenious novelty is the series of "Claudegen" interchangeable window devices announced by the General Electric Co., Ltd. These compact neon signs, in red, blue, or green, will each fit on a standard base, so that they are readily interchangeable. They operate only on A.C. supply. These displays should serve to arrest the attention of passers-by, and should prove a useful adjunct in the show window. In the list before us, twenty different models are illustrated.

"Nuway" Electrical Accessories

In studying the exhibits at the British Industries Fair, one was struck by the extraordinary variety of electrical devices now made in plastic material and by the many convenient "gadgets" on offer. Among these were several novelties introduced by the Nuway Electrical Accessories Co., such as the "Nuway" screwless lamp-holder and ceiling roses, and an ingenious safety thief-proof lamp-holder.

The firm also supplies a special insulating skirt for use with lamp-holders in factories and damp situations.

B.T.H. at Olympia

One looks for some novelty on the part of lighting firms at the Ideal Home Exhibition. The Mazda stand, with its display of coloured-lighting surrounding a woodland centre-piece, was effective—every type of Mazda lamp was shown, and could be switched on at will.

The chief novelty, however, was the display in B.T.H. Hall in the gallery, where displays of "electrical magic" proved highly popular. Another feature was the series of six alcoves, each containing a Mazda "Dancing Girl" statue, illuminated by changing coloured-lighting.

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